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NATURAL AND ENERGY RESOURCES

Eston T. White

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PREFACE

This text describes the status of the more important natural and energy resources, particularly those of importance to national security, and the extent of U.S. vulnerability resulting from dependence on foreign suppliers. The book also examines measures to improve the U.S. position on natural and energy resources, as well as problems relating to resource development and use and quality of the environment. The fundamental role of private enterprise in the development and processing of resources, though not discussed as a separate topic, is evident throughout the text. Since national security managers should be acquainted with the Federal Government's role in matters relating to energy and material resources, considerable attention is given to this subject.

The materials in this text relate to other volumes in the National Security Management series, particularly *Transportation* and *Mobilization Preparedness*. Human resources are examined in *Human Resources and Defense Manpower*.

This volume includes the major subject areas covered in *Natural and Energy Resources* (1979), and a chapter has been added on strategic and critical nonfuel minerals. The material on most subjects in the earlier text has been completely recast and updated. The present volume weighs the impact of science and technology, of environment factors, and of U.S. competitiveness on supplies of material resources.

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The contributions of several persons in the writing or rewriting of chapters deserve special attention and acknowledgement. Val E. Hendrix, Colonel USAFR, contributed data and wrote some sections of chapter VIII on energy and chapter IX on ocean resources. Mr. Calvin B. Kelley revised and updated chapter III on water. Colonel James Longhofer wrote chapter IV on agriculture and food, and his efforts in producing an interesting account are gratefully acknowledged. Mrs. Yvonne J. Carter deserves special thanks for her work in updating and revising chapter V on forest resources. The contributions of Paula Kerr and Calvin Kelley in editing and preparing the manuscript for printing are gratefully acknowledged.

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I

INTRODUCTION

An abundance of natural resources has been a basic factor in the Nation's rapid development as a world power and in the attainment of the very high standard of living Americans enjoy. Usually defined as those materials found in nature that are available to people, natural resources include water, minerals, sources of energy, land, and the products of the land. Bounteous supplies of resources alone do not assure national strength or a high standard of living; much depends on other factors such as a society's organization for production, its transportation, its level of technological development, and its human resources.

It is important to distinguish between available usable natural resources and the mere existence of resources. In an undeveloped country, rich deposits of iron ore in a remote and inaccessible location may be of little value; even in a highly developed country, large deposits of a particular substance containing elements of value, for example shale oil, may have to await development because production costs and environmental considerations stand in the way.

The assurance of adequate supplies of energy, minerals, metals, and food; the maintenance of a favorable balance of ecological systems; and the development of human resources, as well as technology, are essential elements of national strength. In the cold war period national security considerations tended to focus on the military aspects of foreign threats. Since the mid-1960s, however, natural resources as elements of national strength have become increasingly important. The world shortages of materials and energy that got worldwide attention in the 1970s have tended to highlight the role of natural resources in international relations.

CHANGING RESOURCE SUPPLY AND DEMAND

The consumption of raw materials expanded rapidly in the 20th century and particularly after the Nation entered into the mass consumption phase of economic development in the 1920s. Overall, until mid-century, the domestic resource base afforded a high degree of self-sufficiency in raw materials. Resources were generally used with little or no concern that they might become depleted. Stewart L. Udall, a former Secretary of the Interior, in describing the traditional philosophy of resources use said:

> It was the intoxicating profusion of the American continent which induced a state of mind that made waste and plunder inevitable. A temperate continent, rich in soils and minerals and forests and wildlife, enticed men to think in terms of infinity rather than facts, and produced an overriding fallacy that was nearly our undoing—the Myth of Superabundance. According to the Myth, our resources were inexhaustible. It was an assumption that made wise management of the land and provident husbandry superfluous.[1]

Natural resource shortages developed during World War II, and the United States became dependent upon foreign suppliers for many materials. After the war the demands for natural resources brought renewed interest as the warworn economies of Europe and Japan were being restored. President Harry S Truman established the Paley Commission to make a detailed study of current and future materials supplies. The Paley Report, often considered to be the first major attempt by the Federal Government to make a careful evaluation of resource adequacy, pointed out that in the United States the supplies of the evident, the cheap, and the accessible are running out.[2] The report's emphasis was not on depletion, but rather on availability at a cost, on the role of costs as a barometer of scarcity, and on technology as a factor in determining available supplies and costs. Another Presidential commission investigated water resources in the early 1950s, as concern about possible water shortages became widespread.

Relatively few people were then taking the possibility of resource shortages seriously. Economic growth and consumption were moving ahead steadily in the United States, and foreign demand, particularly for U.S. high technology products, was steadily increasing. Government leaders, economists, and the public came to accept the belief that expansion of the economy was critical to the Nation's economic well-being; further, they believed that a crisis situation in supplies of resources could be averted by paying the price it would take to increase domestic production of a particular resource or by relying on foreign suppliers. The measures considered to offer opportunity for increased production of resources in short supply included the development of new technology, incentives to increase exploration and discovery, the mining or extraction of lower quality raw materials, and tax concessions to resource producers.

In analyzing shortages, one should be aware that they may result from one or more causes, including the following: lack of raw materials, lack of capacity or incentives to produce secondary materials or energy, market difficulties, and problems in the distribution system. For example, in the mid-1970s natural gas was withheld from the interstate market because intrastate prices in some gas-producing States were higher than the controlled prices of interstate gas. This situation contributed to shortages for consumers in an environment where annual consumption of gas was exceeding additions to reserves, and total reserves were estimated at less than a 10-year supply at then current rates of consumption.

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[1] Stewart L. Udall, *The Quiet Crisis* (New York: Holt, Rinehart & Winston, 1963), p. 54.

[2] The President's Material Policy Commission, *Resources for Freedom*, 5 vols. (Washington: Government Printing Office, 1952).

In the early 1960s works such as Rachel Carson's *Silent Spring* and Stewart Udall's *The Quiet Crisis* alerted the public to the accelerating use of the environment and the degrading effects on resources. Increased consumption is reflected in the fact that in terms of constant dollars, annual growth in gross national product (GNP) was $25 billion from 1958 to 1965 as compared to $4 billion in the period of rapid expansion from 1922 to 1929.[3] The efforts of environmentalists helped to broaden the study of America's future and to force consideration of the interaction of population growth, food production, industrialization, pollution, and the consumption of nonrenewable natural resources. Except for periods of depression, Americans tended to think of growth as a linear process: the adding of successive increments to productive efforts and the using of finite amounts of various resources. The facets of economic activity were generally examined separately. Since the mid-1960s, however, assessments of growth have usually given greater attention to the interaction and relationships of factors and to the worldwide resource supply-and-demand picture. Also, there has been more awareness of those areas that grow exponentially (such as pollution) and of the implications for the future. In the context of world population growth and of increasing pollution, the question of placing limits on U.S. economic growth has been raised and discussed at length.

In terms of self-sufficiency, the United States was a net exporter of raw materials until 1963. In 1964 the favorable balance of trade in minerals was reversed. By 1969 the net deficit in minerals had grown to $4 billion. The oil crisis of the 1970s greatly increased the adverse trade balances in raw materials that began in the 1960s. Although the United States produces more than 80 percent of the minerals it has consumed in recent years, it is dependent on foreign suppliers for more than 50 percent of total consumption of some 25 critical minerals or metals.

It became more and more apparent in the 1970s that the U.S. resource frontier, with its abundance of raw materials at low cost, was at an end.

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[3] Sterling Brubaker, *To Live on Earth* (Baltimore: Johns Hopkins University Press, 1972), pp. 16-17.

The gap between natural gas supplies and demand increased, and reliance on petroleum imports rose rapidly as domestic crude production dropped. The rapid growth in world consumption of oil in the early 1970s exacerbated the U.S. fuel problem. Also, U.S. demand for fuels experienced rapid growth; from 1969 to 1973 the annual growth rate for petroleum was more than 5 percent, for natural gas 4 percent, and for electricity more than 6 percent. As the world's leading energy consumer—annually accounting for approximately one-third of world energy consumption—the United States was and is a major influence in world energy markets. The petroleum crisis in the United States following the outbreak of the Arab-Israeli conflict in the fall of 1973, and the oil embargo brought attention to our heavy reliance on oil imports; the reliance had actually already developed before the embargo began. The level of imports was even higher during the remainder of the 1970s.[4]

Energy shortages have a reverberating effect that affects many parts of the economy. Gasoline shortages in early 1974, for example, restricted travel and caused cutbacks in the many activities associated with recreation, such as lodging and sales of outdoor leisure equipment. Shortages of natural gas and propane to meet industrial needs reduced the production of petrochemicals used for synthetic fibers, fertilizers, and many other products. The 1973-74 energy crisis may have lowered the gross national product by $25 billion.

The Nixon Administration's response to the energy crisis was a call for self-sufficiency in energy resources. When the Arab embargo was imposed, total imports were about 30 percent of total U.S. oil consumption. By the beginning of 1978 dependence on oil imports had increased to nearly 50 percent, and the goal of self-sufficiency by 1985 was considered well out of reach.

In 1985 the United States was still not self-sufficient, but the changed situation was a welcome surprise: The U.S. demand for oil had significantly decreased; dependence on Organization of Petroleum Exporting Countries (OPEC) imports had fallen from 17 percent of our needs in 1977 to 4 percent in 1983; and imports had increased from countries such as Mexico, Canada, Venezuela, Indonesia, and the United Kingdom.

By early 1985 the Strategic Petroleum Reserve (SPR) had been built up to more than a 90-day emergency supply level to reduce U.S. vulnerability to interruptions in imports.[5] Other measures including conservation and technological improvements have also lessened U.S. dependence to some extent, but a degree of vulnerability remains.

In terms of elementary economics, solutions to scarcities are accomplished by increasing supply, by decreasing demand, or by both.

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[4] Brubaker, *To Live on Earth*, pp. 16-17, and Resources for the Future, Inc., *Annual Report*, 1973 (Washington: Resources for the Future, 1973), p. 4.

[5] U.S. Department of Energy, *Progress in Energy, 1983-1984*, p. 3.

Before the shortages of natural gas and petroleum in the 1970s the emphasis was almost entirely on increasing supplies to keep the economy running at a record clip. By 1973, when the rate of inflation jumped, there was evidence that efforts were being made to lessen demand. Policymakers urged reductions in demand to slow the economy in the mid-1970s, but in the early 1980s, as energy became less of a public concern, policy tended to move back to increasing supplies of energy.

MAJOR FUTURE INFLUENCES

Three factors that will have a strong bearing on pressures for resources, if the growth rates of the economy of recent years are maintained, are population growth, developments in technology, and actions to preserve the quality of the environment. At this point, only the general implications of these factors will be discussed; later chapters give more details as they apply to specific types of natural resources.

Population Growth

The forces underlying the rapid rise of resource consumption are population growth and increased personal income. From 1950 to 1980 population increased from 151.3 million to 226.5 million. Personal income per capita measured in 1972 constant dollars increased from $4,265 in 1970 to $5,392 in 1982.[6]

The implications of continuing U.S. population growth on supplies of resources and the environment have been studied at various times in the period since the 1960s. Compared to many less developed nations, it should be noted, the United States has felt the effects of surplus population only slightly. Natural population growth in the United States in the mid-1980s was approximately .7 percent annually while many less wealthy nations were experiencing annual growth rates of 2 percent or higher. The case for zero-population growth in the United States has not been proven and, furthermore, demographers do not agree how long it would take the United States to reach zero-population growth at given fertility rates. If only material factors are considered in making judgments on the quality of life in the United States and income distribution is ignored, the evidence strongly indicates that there has been improvement. Per capita gross national product has increased and the level of living has improved. Policy issues arise from the fact that high levels of consumption are depleting our limited reserves of various raw materials. Also, there has been growing damage to the environment from extractive, consumptive, and disposal practices. In some cases, decisions must be made as to whether we want to pay the price of preventing pollution or to continue to pollute the environment. The use of high-sulphur coal illustrates this issue. Sometimes jobs are lost when activities are shut down because their operation is damaging the environment.

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[6] U.S. Bureau of Census, *Statistical Abstract of the United States, 1984*, 104th edition (Washington: Government Printing Office, 1983), pp. 6 and 457.

The perspective on population of the Commission on Population Growth and the American Future is reflected in the following excerpt from its report summary in 1972.

> Finally, continued population growth closes off options. In the case of the larger population, there is less land per person, less choice, less room for diversity, less room for error. Technology must advance; life styles must change. Many may like this emerging world; but for those who do not, there will be fewer alternatives.
>
> To emphasize the point, it is tempting to exaggerate the importance of population as opposed to economic growth in causing these social costs, and to over-emphasize the difference that a slowdown in population would make. But in such an emphasis perhaps we come closer to the heart of the problem of population growth in this country. For a rich, technologically sophisticated and flexible country like the United States, adequacy of resources and control of pollutants are not seriously in doubt during the next half century; we can conquer these problems if we wish. The real question is whether we will like the society that conquering these problems entails.[7]

Science and Technology

Experience has shown that science and technology can have a very great impact on available supplies of resources. In fact, science and technology have made such great progress in discovering new substances, new sources of energy, and new processes for utilizing natural resources that many people expect technological breakthroughs to go on raising physical ceilings indefinitely. Former President of the Population Council Frank W. Notestein, for example, has said that no real limitations exist in either raw materials or energy that "alterations in the price structures, product substitution, anticipated gains in technology and pollution control cannot be expected to solve."[8] Not everyone shares the optimistic view of a future based on technological solutions to resource problems, and some see the need to limit growth.[9]

The art of technology forecasting has not been developed to the degree that it inspires a great deal of confidence; but on the other hand, projections of resource supply and demand made by those who have tried to show the need for limiting growth contain estimates of variables that may or may not be accurate. Therefore, the forecasts of the status of supplies of a resource a decade or more in the future are to a large extent conjecture.

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[7] Ronald G. Ridker, ed., *Population, Resources, and the Environment*, Report of U.S. Commission on Population Growth and the American Future (Washington: Government Printing Office, 1972), pp. 31-32.

[8] "Zero Population Growth: What Is It?" *Family Planning Perspectives 2* (June 1972): 20.

[9] See Donella H. Meadows and others, *Limits to Growth* (New York: Universe Books, 1972) and Lewis J. Perelman, *The Global Mind: Beyond the Limits to Growth* (New York: Mason/Charter, 1976).

Advancements in science and technology are found in a wide variety of fields relating to resources, and it is most difficult to aggregate and generalize their dynamic implications. In many instances the positive gains in increased production and efficiency from improved technology must be weighed against socio-economic costs. For example, the development of a new machine or a new process may cause serious dislocations in the work force, or considerable costs may be involved in repairing the environmental damage incurred by a new technology.

Science and technology have been a major, but not the only, factor in increasing the annual output of a number of resources. New strains of plants, improved practices in production, and many other technological advancements played a large part in making it possible for the American farmer to produce over six times as much per man-hour of work today as in 1930. Though less impressive in many other resource fields than in the agricultural, productivity increases over all have nevertheless been large. Generally, improved technology has been a leading contributor to increased output of minerals, metals, and timber products over the past two decades.

Environmental Programs

The extent to which environmental considerations affect supplies and the uses of resources has been under extensive study and investigation in the past few years. In its final report, in June 1973, the National Commission on Materials Policy observed:

> The material resources and environmental quality of the Nation are affected by a lack of consideration of the two as a unit. Depletion of reserves and pollution have the same cause – failure to manage the flow materials as a cycle, resulting in a resource depleting dispersal of energy and materials into the environment as pollutants. A national policy for the management of energy and materials is needed to transform this open-ended process of wastage into a substantially closed system. The goals of environmental quality require a comprehensive system of resource recovery: the recycling of materials through the economy with minimal losses in matter and energy.
>
> Problems of reconciling environmental, land-use, and materials policies are made more difficult by insufficient knowledge, awareness, and understanding of basic interactions of natural and technical systems. Wisely selected and carefully organized data are required to guide policy decisions that will allocate the available resources and uses of the environment if the Nation is to achieve progressive gains in the quality of life for this and future generations.[10]

The establishment of standards that are desirable, and at the same time reasonable, poses particular problems. Problems arise, for example, in programs for the development of new resources or for the expansion of old projects because choices between increasing output and degrading the environment must be made. In many cases there is the option to increase output while preserving the environment but with added costs. These costs, resulting from the prevention or repair of damage, are known as external diseconomies.

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[10] National Commission on Materials Policy, *Material Needs and the Environment Today and Tomorrow*, Final Report (Washington: Government Printing Office, 1973), p. 6-1.

The causes of pollution and the evidences of deterioration of the quality of the environment are not hard to find. Basically, much of the difficulty flows from the concentration of people and activity in urban areas and the consequent polluting of the air, water, and land beyond the limits of nature to absorb or hide this polluting, or to dilute the unwanted gases, fluids, and materials. The general reluctance of people to stop littering or to pay the costs of reducing pollution are also fundamental problems. American society is not only affluent. In its consumption habits it is effluent. The United States has 6 percent of the world's population, but it produces an estimated 70 percent of the world's solid wastes.[11] Although the major blame for pollution is frequently attributed to a particular segment of society, the casual chain of deterioration points to people generally: too many factories, too many cars, inadequate sewage treatment plants, too many pesticides, too much detergent, multiplying contrails, and too little water. The environmental revolution that began in the mid-1960s was prompted by the sudden awakening to the evidence that the ecosystem was being driven toward collapse and by realization of the links between ever-increasing population growth, ever-expanding per capita consumption, and pollution.

An early conservation movement, which reached its peak in the first decade of the century, was a practical propaganda effort intermixed with the considerable idealism of a few forward-looking men such as Gifford Pinchot. Despite lack of broad public support, it made some headway toward protecting resources, perhaps foremost among them being the increase in acreage of national forests under the U.S. Forest Service. This effort was more toward improving the use of resources, however, than toward achieving a balance with nature in resource exploitation. One purpose behind the movement was to persuade the public that the natural resources of the West should belong to all the people rather than to States, corporations, or individuals.

A major difference between the early conservation movement and the environmental revolution of the 1960s was the latter's much greater costs to economic growth. At the beginning of the century the market price of a product was largely the index of its marginal value to society; by the 1960s external diseconomies were being generated either in the process of production of certain goods or in their final use, inflicting damage on society, adding to production costs, and contributing to higher market prices.

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[11] Barry Commoner, *The Closing Circle* (New York: Knopf, 1971), p. 7.

Although there was considerable evidence when the environmental revolution began of a general trend toward deterioration, the development of environmental indices and the measurement of indicators have not been worked out satisfactorily. Consequently, the formulation of environmental programs and the assessment of their impact on resource production and use are difficult. A primary aim of the Council on Environmental Quality, whose chairman is the head of the Environmental Protection Agency (EPA), is to encourage the development of a better system to measure the condition of the environment and to find whether particular facets of environmental quality are improving or deteriorating. If more relevant data on environmental conditions were available, decisionmakers and the public would be greatly aided in the establishment of priorities and the evaluation of programs bearing on resources.

The major result in government of the environmental revolution has been the antipollution laws passed at Federal, State, and local levels. A milestone was reached in 1969 with passage of the National Environmental Policy Act. This act established the Council on Environmental Quality and requires Federal agencies to prepare and submit environmental impact statements on programs and projects that could significantly affect the environment. To fight pollution, acts have been passed to deal with clean air and clean water, solid waste disposal, and the control of discharges containing radioactive substances and toxic substances. While measures to preserve the environment have lessened pollution, they have also tended to slow down the exploitation of resources where deterioration of the environment is a concern (for example, strip mining and atomic power development). Antipollution measures have also increased the costs of some resources. With the development of an energy crisis in the early 1970s, the United States was confronted with the need to make choices on programs that related to standards for air and water quality and the maintenance of the natural landscape. In many cases economic pressures tended to slow progress toward environmental goals.

The close relationship between resource development and preservation has been demonstrated clearly in many facets of development since the 1960s. Simultaneous efforts to increase output and to promote the environment frequently run into difficulty and sometimes cause dilemmas. Increased production costs resulting from measures to preserve the environment are often a factor in maintaining American competitiveness with foreign suppliers. A continuing question is how many jobs is the American public ready to sacrifice for environmental preservation when competitiveness is a factor. Public support for environmental programs, especially when health is an issue, continues to be strong.

INTEGRATION OF GOVERNMENT EFFORTS

Because the development of resources has been highly dependent on private enterprise, Federal controls have traditionally been instituted only when Congress believed them to be essential. Through the first century or more of our Nation's history congressional action concerning resources was directed largely to measures making federally owned resources available and developing the infrastructure necessary for their exploitation. Over the last half century and particularly since the early 1960s, Federal controls have been oriented to a much greater extent on regulating facets of resource development that involve conflicting interests of different groups, questions concerning environmental impact, and the continuing issue of conservation. Developments in recent decades have contributed to a greatly expanded role for the Federal Government. The United States no longer enjoys the high degree of self-sufficiency in resources that permitted the Nation to take an independent course in world affairs up to World War II. Shortages have appeared, most noticeable in petroleum, and many interdependencies involving reliance on foreign suppliers have developed. While the Reagan Administration tends to favor reduction of Government controls, many people look to Washington for solutions to the Nation's resource problems and related environmental issues.

The Federal machinery for dealing with resources took shape as Congress passed successive laws to meet new requirements. In the early years of the Republic, responsibilities for resources tended to fall mainly under the Department of the Interior. Later, more departments were formed, the problems associated with a particular resource became more complex, and responsibilities tended to be divided; in recent decades the responsibilities have frequently fallen into a half dozen or more departments or agencies. In some cases, there was duplication of effort and confusion because responsibilities were not clearly defined.

President Nixon recommended legislation to create a Department of Natural Resources in 1971. In June 1973, when management of energy was becoming a serious problem, he modified his earlier proposal and called for a Department of Energy and Natural Resources. The energy crisis in late 1973 and early 1974 made reorganization of administrative agencies imperative. The Federal Energy Office was created by an executive order of 4 December 1973 to deal with the energy problem; and the following May the Federal Energy Administration Act of 1974 created a successor agency, the Federal Energy Administration. Other legislation in 1974 authorized the Energy Research and Development Administration and the Nuclear Regulatory Agency to replace the Atomic Energy Commission and the Energy Resources Council to coordinate Federal programs.

As one of his first moves toward Government reorganization, President Jimmy Carter proposed an Energy Department on the theory that existing agencies lacked coordination and an authoritarian figure of cabinet-secretary rank. The Congress quickly passed legislation for a new Department of Energy (DOE) that became operational on 1 October 1977 with authorization for approximately 20,000 employees and a budget of $10.6 billion. James R. Schlesinger, an economist and former Secretary of Defense, was named to head the new department.

Creation of the Department of Energy involved blending of three major agencies: the Federal Energy Administration, the Energy Research and Development Administration, and the Federal Power Commission along with a number of smaller agencies. Congress refused the President's request to give the Secretary of Energy complete authority over the pricing of energy. Instead, the authorizing legislation created the semiautonomous Federal Energy Regulatory Commission of five members within the Department of Energy to regulate energy prices.

RESOURCES AND STRATEGY

Abundant material resources and the ability to develop a strong infrastructure to utilize resources were major elements in the emergence of the United States as a leading power. Other factors were also important, including human resources and technology and a political and social environment that generally fostered economic growth. In terms of gross national product, the United States has held the world lead since World War II. Also, it has maintained a leading position in technology.

Resources, economic strength, and the capabilities to maintain formidable military forces continue to play a significant role in the struggle for power between the United States and the Soviet Union in the 1980s. The enormous economic assets and technological capabilities of the United States are pillars of strength that are respected by friend and foe. However, the increased dependence of the United States on foreign suppliers for materials, products, and services, particularly since the 1960s, has brought vulnerabilities. (The vulnerabilities relating to strategic and critical materials and energy are discussed in later chapters.) Reliance on allies and Third World nations, some of doubtful reliability, for materials critical to national security has increased significantly. In turn, the security of lines of communications and transport routes for materials have become more important.

Some argue that if there were an all-out nuclear war, only those resources and capabilities on hand or available in the near term would count. Therefore, they say dependence on foreign sources and secure lines of communication to obtain needed materals and energy have little significance. Considering the conditions of today and the past decade, it appears that being prepared for possible conflict short of nuclear war continues to be essential. Adequate supplies for war, including strategic and critical materials and energy, are essential parts of preparedness. Maintaining competitive U.S. extractive, processing, and manufacturing industries is a first priority in meeting U.S. peacetime needs and potential emergency requirements. Nevertheless, the United States has become dependent on foreign suppliers for some materials for various reasons; these reasons include the lack of a resource base, (for example, manganese) and the failure to maintain competitive mining or processing industries.

After the 1973-74 OPEC oil embargo the threat, and perception of a threat, of possible Soviet expansion into Middle Eastern oil producing areas and control of lines of communication for oil transport led directly to the development of the Rapid Deployment Force (RDF) and to U.S. increased military presence in the Indian Ocean. Soviet efforts to expand their influence in Africa—particularly in those areas of strategic importance because of their location with respect to lines of communication or their critical resources—have entered into U.S. strategy calculations. Southern Africa and northeastern Africa are of particular importance.

Views vary as to the likelihood or degree of conflict over resources. One view foresees a rising tide of mercantilism involving protectionism and trade wars with greater concern for protecting access routes and a scramble for undeveloped resources, particularly those offshore. This point of view predicts a world environment in which incidents involving force are more likely to occur. Those who are more optimistic see emerging patterns of economic interdependence, easing of the scarcity problems, and increasing cooperation in working out controls over ocean resources and other controversial areas.[12]

Three categories of military issues arise from the growing scarcity of resources and are of interest because of the possibility of U.S. involvement directly or through community interest. First, military conflict could begin through efforts to control, destroy, or to protect a particular resource such as an oil field or area containing critically important minerals. Second, military deployments could be used to annex or protect areas critical to the control of valuable or potentially valuable resources. Third, military conflict could begin over access routes to and from sources of supply involving air, land, or sea communication. The resource factor could be of predominant importance in the precipitation of any of the three categories of possible military action outlined or it could be of secondary concern. For example, in the cold war in recent years between Great Britain and Iceland, the fish resource was the dominant factor while in the recent Greek-Turkish conflict over possible oil deposits in the Aegean Sea, the resource was a secondary factor.

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[12] Geoffrey Kemp, "Scarcity and Strategy," *Foreign Affairs* 56 (January 1978): 396-414.

The possibility for the use of force to secure resources was evidenced in Henry Kissinger's 1974 reminder (in a veiled threat to the Middle East oil producers who had imposed an embargo) that states have on occasion gone to war for that purpose. Protection and surveillance of regional sea areas, now considered international by sea patrols or other measures, have increased in recent years as competition for fishing and other ocean resources has intensified. Soviet improvements in capabilities to conduct distant operations and to provide strategic lift capability for surrogates, such as Cuba, have increased Soviet abilities to exercise political-military influence in Africa, Latin America, and other Third World areas where U.S. and Soviet interest conflict.

The prospects are for continuing conflict of interest between the two superpowers in areas of great importance to the United States and its allies for supplies of critical resources. U.S. dependence on foreign suppliers for oil and strategic and critical materials demands that U.S. policies, both domestic and foreign, take into account the resource interests and responsibilities of our allies and the need for cooperation with them; also, the United States must consider the continuing efforts of the Soviet Union to gain control over areas of strategic importance because of their resources or their location on strategically important lines of communication. The challenge for policymakers and U.S. national security managers is to get allied nations to recognize their responsibilities for resource security and to contribute their fair share.

II

LAND: OUR HERITAGE

A plentiful supply of land to fulfill a great variety of needs has given the United States a firm foundation for its economic development. Further, Americans, as most other peoples of the world, are highly dependent on the products of the land for food, fiber, wood for building shelter, and many other items and uses. Although still vital, land has declined in relative importance to the individual and to the economy as the Nation has developed from a largely rural and agricultural society to an urban-industrial society in which the manufacturing and service sectors have overtaken the extractive industries in their contributions to the gross national product. Still, after equipment and structures, land is the largest single component of national wealth. More than 25 percent of all real estate value in America is in land.[1]

During the agrarian period of American history, generally the era before the Civil War, land was basic to personal income and to the maintenance of households. Land ownership was of major importance as a measure of social standing or prestige in the community and as a force in politics. The transformation to an industrial society opened opportunities for individuals and corporations to gain a strong financial position from nonagricultural endeavors. Urbanization brought about the rental of property on a broad scale, and land ownership began to lose its influence as a prestige symbol, particularly after the end of the 19th century. The frontiers that had given people an opportunity to obtain productive land at bargain prices had nearly all been settled by the end of the 1890s. During this same decade the contribution of manufacturing industries equaled that of agriculture as a share of gross national product for the first time.

The Federal Government at various times in earlier years held title to as much as 80 percent of the Nation's land. Today, the Federal Government owns about one-third of the land. Federal, State, and local governments, together, hold about 40 percent of the Nation's total land area of 2.3 billion acres. For private owners the figure is 58 percent, and Indians hold about 2 percent of the land. The Government dispersed 1.14 billion acres of public lands between 1781 and 1982. Almost 328.5 million acres were granted to States, 287.5 million acres were granted or sold to homesteaders, and the remainder went for other purposes.[2] About half of the Federal acreage today is in the Mountain and Pacific regions of the West, and most of the remainder is in Alaska. In 1982 the percentage of Federal ownership was highest in the following States: Nevada, 86.1; Idaho, 63.8, Utah, 63.6; Alaska, 59.6; Oregon, 52.5 Wyoming, 48.7; and California 46.6. Very little of the acreage in Federal lands is physically suitable for crop use, but the resources on and under the lands are extensive.

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[1] For more detailed accounts of land see Peter Wolf, *Land In America* (New York: Pantheon Books, 1981) and Marion Clawson, *The Federal Lands Revisited* for Resources for the Future, Inc. (Baltimore: Johns Hopkins University Press, 1983).

Data on land ownership by foreign entities are not readily available, and this is partly because foreign investors do not want to be identified for tax purposes. According to data published by the U.S. Government, 13.5 million acres of agricultural land were owned by foreign interests in 1982. Canada was the largest owner and the only country to hold more than 10 percent of the total. Canada was also the largest holder through U.S. interests with nearly 20 percent of that category, while the next largest holders were Hong Kong with 12.6 percent and the United Kingdom with 11.2 percent.[3]

Compared to people of most other nations, Americans are very fortunate in their land heritage. The per capita land surface of the United States—almost 10 acres, the equivalent of 10 football fields—is almost exactly the same as the world average; however, the land of this country is far more productive on the average than that for the world as a whole. Of the total U.S. land area of approximately 2.3 billion acres, not more than 10 to 15 percent is wasteland, and even some of this small part supports wildlife or makes a contribution as watershed or in some other way. About 55 percent of the total acreage is used to produce crops and livestock; and of this 55 percent some 21 percent is classified as cropland.

The vastness of the land area and the multitudes of landscapes in the United States are not appreciated by many Americans because they travel outside urban areas only by air or through corridors of superhighways that are often shut off from interesting terrain features. The country's topography and land formation, even within main geographical divisions, have many variations, each one delineated because of dominating characteristics. Geographers differ somewhat as to the names and areas included in the main geographical divisions of the conterminous States, but the divisions usually approximate the following: Atlantic Coastal Plain, Piedmont, Appalachian Mountains, Central Lowlands, Gulf Coastal Plain, Great Plains, Rocky Mountains, Sierra Nevada Mountains, and the Pacific Littoral.

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[2] U.S. Department of the Interior, *Public Land Statistics, 1982* (Washington: Government Printing Office, 1983), pp. 1 and 5.

[3] U.S. Bureau of the Census, *Statistical Abstract of the United States 1984* (Washington: Government Printing Office, 1984), p. 657.

Of a particular land resource area, the dominant physical characteristics that bear on its value are soil, topography, climate, and moisture. While the proper combination of these factors may tend to give land potential value, it is the way in which a particular area fits into our scheme of activity that determines its current value. For example, a plot of land that is of little or no value for agricultural purposes but that is wanted for a planned shopping center in a metropolitan area may sell for a great deal. The same size plot of rich, highly productive agricultural land in, say, Iowa may sell at a small fraction of that price.

In the United States there are thousands of different kinds of soils. To classify them, soil scientists have worked out a system of soil orders, suborders, great groups and subgroups, families, soil series, and soil types. Field observations and laboratory tests and measurements are used to make determinations and to affix proper descriptive nomenclature. This knowledge of soils is important to all users of the land whether their interest is in farming, conservation, or in the extractive industries, because soils are a major factor in determining whether an area is suitable for growing a crop or for locating a particular activity.[4]

LAND USES

Land is a many-faceted resource—to the farmer, a livelihood; to the writer, a theme; to the industrialist, a place to locate a plant; to the economist, a resource contributing to the productive process. Attention in this text is focused on the land resource as it relates to agriculture, forests, mining, urban use, recreation, and miscellaneous uses. Separate chapters are devoted to discussions of the first three; the others are discussed in this section.

Conflicting priorities have shaped American attitudes toward the land and the environment. On the one hand, land in its utilitarian role is a commodity serving our needs for food, building materials, and other purposes. On the other hand, it has "higher" uses that involve esthetic and spiritual values and our emotions. Although Ralph Waldo Emerson and Henry David Thoreau attempted to awaken Americans to these higher values in the environment in the 1830s and 1840s, the competing claims between the utilitarian value of land, which stood at the top in the order of priorities, and the higher values, which were low in the order in Emerson's and Thoreau's time, did not come into sharp conflict until almost a century later.

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[4] For additional information on soil classification see Louis A. Wolfanger, "Soil Orders and Suborders of the United States and Their Utilization," in Guy Harold Smith, ed., *Conservation of National Resources*, 4th ed. (New York: Wiley, 1971); U.S. Geological Survey, *The National Atlas of the United States of America* (Washington: U.S. Department of the Interior, Geological Survey, 1970), pp. 85-88.

Many changes have taken place in the American economy since 1920, but the amount of land devoted to each major use has remained relatively constant. The acreage in each category in 1978 was: cropland 471 million acres; grassland, pasture, and range 587 million acres; forest land 703 million acres; transportation, recreation, and other special uses 158 million acres, and miscellaneous land 345 million acres. Percentages for land use are at figure 1. One of the more significant changes in the 1970s was the reversal of the downward trend in cropland acreage. The use of land for agricultural purposes will be discussed in greater detail in a later chapter.

Urban Land

Although urban areas total only about 35 million acres or scarcely 1.5 percent of the land, some 70 percent of the population of the United States resides there. Not unexpectedly, the most difficult problems related to land use are found in urban areas. Before discussing further the importance of urban land, let us clarify the terms "urbanized area" and "standard metropolitan statistical area" (SMSA), both used in referring to metropolitan population centers.

The Bureau of the Census established the concept of the "urbanized area" for the 1950 and later censuses by delineating areas actually used for urban purposes. The discontinuity of settlement on the fringes of cities, however, makes it difficult to set exact limits. Furthermore, the same rules for setting limits have not been used for the various censuses; therefore, caution is advised in comparisons of data. The standard metropolitan statistical area has a population of 50,000 or more and includes a core city or cities. It may also include one or more counties. The concept has been developed to facilitate the collection of data and the study of many aspects of the changing city such as population trends and employment. As a tool for the study of land use, however, the SMSA definition is limited, largely because it includes much rural land. In 1970 the average distribution of land use within an SMSA was: urban 10 percent; cropland 24 percent; pasture 19 percent woodland; 32 percent; and other 15 percent. "Suburb" generally refers to a residential area within an SMSA but outside the central city.

Data for 1980 indicate that SMSAs account for approximately 16 percent of the Nation's land area and almost 75 percent of total population. The number of SMSAs had grown by 1983 to a total of 329 including 36 designated as such in the period following the 1980 census. During the period 1950 to 1970 the population of metropolitan areas increased from 97 million to 150 million. Most of the newcomers were unfamiliar with city life and represented minority groups, a condition that tended to cause urban disarray.[5] In our overall internal migration

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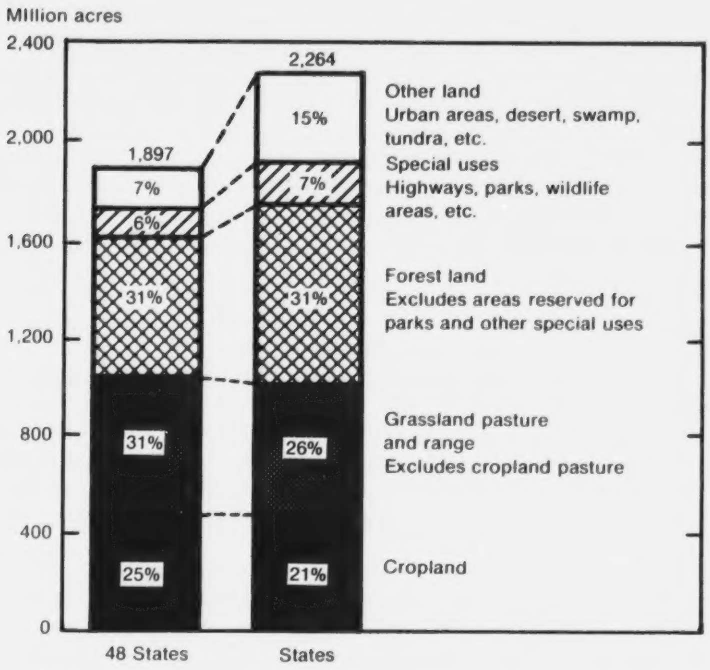
[5] See Charles H. Stoddard, *Looking Forward* (New York: Macmillan, 1982) for further information.



Source U.S. Department of Agriculture

FIGURE 1. MAJOR USES OF LAND, UNITED STATES, 1978

there was a pronounced shift from the Northeast to the South and West from the 1970s onward. Although the Northeast was still losing population to the South and West in the 1980s, the flow slowed and the Northeast was again growing in total population.

In urban areas, land use and the value of a particular piece of land are determined largely by the nature of the activities in the general area or neighborhood. External influences, such as those in the immediate vicinity of a plot of land, and interdependence with adjoining or nearby properties have a far greater bearing on land value and the options available for land use in urban areas than in rural areas. Zoning ordinances are the most powerful part of land law in America. Of all cities with populations of over 10,000, 98 percent have a zoning ordinance, and most of the smaller municipalities also have a zoning ordinance. Marion Clawson, a recognized authority on land resources, in his 1971 study of suburban land conversion was of the opinion that zoning was too weak to be effective in the growing suburbs and that pressures for zoning changes in older developed urban areas were largely offset by counterpressure to retain the status quo. He concluded that "a legal expression of a general plan is essential for growing suburbs, but it is unlikely to be effective unless complemented by other measures of control."[6]

Although State and Federal agencies may have some influence on land use through controls over funds allotted to cities (for example, for urban highways or airports), the pattern of urban development most often flows from the decisions of many groups and their diverse and varied interests and objectives. States and communities, and some multigovernment agencies, are increasingly planning land use, but in many cities the lack of planning and the manner in which decisions are made on the transfer and disposition of land have resulted in a pattern of development that presents many problems—traffic congestion in the central city and on main routes; lack of parking space for automobiles; inadequate public transportation because suburban population is widely scattered; and pollution difficulties from automobiles, factories, and other sources.

The deterioration of older city areas has brought important shifts in land use and a need for renewal or rebuilding. Failure to maintain areas may result because of changes in land use in surrounding tracts, the opening up of new suburbs that are more attractive, or other influences. The retention of slum rental dwellings and buildings has often been encouraged by income tax provisions that allow successive purchasers to charge off depreciation. Public renewal programs have been initiated in many cities, but only a small fraction of the areas needing rehabilitation has been reached. Critics of urban renewal point out that when displaced low-income families are relocated they bring with them old attitudes and that the renewal process is slow and costly. While some decaying areas have been renewed, usually at considerable cost to the taxpayers, the problem of transforming rundown, inner-city areas into attractive and useful real estate remains a major challenge.

Harborplace in central Baltimore is an example of successful rejuvenation of a decaying area. Blending commerce and showmanship, Harborplace in its first year attracted 18 million visitors, earned $42 million, created 2,300 jobs, and returned more than $1.1 million in taxes to the city.[7] Other cities, too, have made notable progress in similar ventures. The renewal of central cities is bringing a return of the white middle class from the suburbs. Smaller cities, too, are fighting decay of central areas.

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[6] Marion Clawson, *Suburban Land Conversion in the United States* (Baltimore: The Johns Hopkins University Press, 1971), p. 5.

[7] *Time*, August 24, 1981, pp. 42, 44, and 46.

Population growth and an anticipated continuing trend toward urbanization will require additional living space and land for the facilities and the services that will be needed in the coming decades. The amount of land required in the future for urban uses, in addition to that already included in urban areas, will depend on the extent to which the undeveloped land in cities is utilized, new suburbs are developed, and new towns are formed. Future locational forces cannot be predicted with any degree of certainty; but indications are that most of the expansion will be in the context of existing cities, and particularly in the growth of suburbs, while some new towns likely will be formed. A recent California law freezing the State's agricultural acreage may be a step that will slow urban sprawl.

The experience with new towns has revealed a considerable gap between concept and reality with a number of failures. Among the more successful communities are those at Columbia, Maryland, and Reston, Virginia. The reasons for the failure of some towns included the private sector's inability to assume responsibilities usually performed by the public sector; decentralization and fragmentation of public service responsibilities; and the low priority in overall planning provided to new communities.[8] Better land-use planning is a major benefit of new community development. Generally, the new towns provide a highly desirable living environment for their residents, but only a few have made significant progress in achieving income, class, and racial balance.

Land for Recreation and Miscellaneous Uses

The use of land for recreational purposes has developed mostly during the past half century. Although many influences have contributed to the development of mass participation in outdoor recreation, increased urbanization and the availability of time for leisure have been fundamental factors. A highly productive economic system has made possible a shorter workweek while it has provided higher incomes. Cheap transportation, largely by automobile, is still another factor in the increased use of outdoor areas for recreation. Outdoor recreation, as traditionally interpreted, includes a range of activities from active sports to more passive activities such as bird watching, walking, or sightseeing. Timesaving technological innovations, a shorter workweek, and early retirement all have been major factors in the post World War II rise of leisure time; they have also been instrumental in increasing the demand for outoor recreation in places specifically set aside for that purpose.

Recreation as it pertains to land is a form of consumption, but unlike use for agriculture and forestry, it is not a materials-producing activity.

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[8] For details on new communities see Raymond J. Burby, III, and Shirley F. Weiss, *New Communities USA* (Lexington, Mass.: Lexington Books, 1976).

In the context of the total economy, however, the use of land for outdoor recreation generates demand for many goods and services, including advertising and publicity, lodging, outdoor equipment, and supplies.

Use of land for outdoor recreation is part of a broad experience, and the study of land requirements for this purpose entails physical, economical, and psychological dimensions of individuals' activities. Recreation usually consists of five separate phases. The first, the anticipation or planning stage, frequently involves purchasing equipment and supplies. The next stage, travel to the outdoor area, may cover any distance and time and may be a small or large part of the total experience. Whether the journey is relaxation or a chore depends much on the attitudes toward travel. The onsite phase at the outdoor area may involve one or several activities such as sports, picnicking, or simply relaxing. The return travel, the next to the last phase, while possibly much like travel to the area, may be quite different as far as route, cost, enjoyment, and other factors are concerned. Recollection, the last phase, takes place after the return trip and may be a large part or a very small part of the total experience, depending on the individual. It is the sum total of the five phases, the weighing of the gains and pleasures against the costs and the pains, that leaves the participant feeling that the experience has or has not been worthwhile. Generally, recreational experiences contribute to good health, give relief from the stresses of daily life, help increase worker productivity, promote family solidarity, and improve self-confidence. One can assume that most people feel that the outdoor recreational experience brings them enjoyment and a certain sense of satisfaction, but it is most difficult to determine the extent of fulfillment that is derived.

The number of participants in outdoor recreation has grown substantially, and their demographic makeup has changed to include people with social and economic backgrounds that significantly differ from those of earlier recreationists. These qualitative changes in the recreating population reflect more than just a higher standard of living and expanded leisure time; they can also be attributed to a redefinition of society's values, new economic forces, and advanced technology. Recreation managers and policymakers must be aware of these cultural shifts if they hope to understand more fully the nature and roots of contemporary recreation trends and their implications for the future.

Recreational visits to federally administered recreation areas have been soaring. From 1950 to 1975 recorded visits to national forests, national parks, and national wildlife refuges increased about 600 percent while use of areas administered by the Corps of Engineers increased more than 2,250 percent. The energy crisis caused a slowdown in recreational visits, but the demand has returned to high levels in the 1980s.

Individuals in the upper age bracket participate in less strenuous activities and the increased age of the population, coupled with other aspects of population dynamics, may cause changes in demand for outdoor recreation.[9]

Many Federal organizations are involved in outdoor recreation. Agencies providing recreation areas, facilities, and services include: the Bureau of Land Management, the National Park Service, the Fish and Wildlife Service, and the Bureau of Reclamation in the Department of the Interior; the Forest Service in the Department of Agriculture; the Department of Defense at various Army, Navy, and Air Force installations, and through the Army Corps of Engineers; and the Tennessee Valley Authority. The Bureau of Indian Affairs also manages recreation lands, but these are not classified as public.

Expectations are that pressures for more outdoor recreational facilities will bring increasing demand for land. Americans almost double their spending every 10 years in the pursuit of pleasure. Experts predict that participation in summertime outdoor recreational activities will increase fourfold from 1960 to the year 2000. The 1977 Outdoor Recreation Survey's medium estimate is that recreation land demand will rise 63 percent by 2030.[10]

The miscellaneous uses of land are varied—water storage and management, transportation routes, mining, defense activities, and several others. Still another category, which includes considerable acreage, is land whose use can most accurately be described as "none." Most of this unused land is desert, swamp, bare rocks, or tundra. Land that is idle but potentially usable is usually included with one of the major land uses. (For example, idle cropland is included in agricultural acreage.)

LAND-USE CONTROL

Social controls over land use have existed in the United States since the earliest years, but they were relatively weak for a long period of our history, and only in recent years have they stirred broad public interest. Virtually all the land in the American colonies and later in the United States was converted to "fee simple" title, or some variant of it; this title conferred a package of individual rights. Conditions during the period of rapid economic development and westward expansion in the United States were favorable for private developments and relaxed controls. Land was abundant and the perception of rural land as a nearly free commodity, in comparison with the value of other factors of production, persisted into the 19th century. Westward expansion and the opening of new lands strengthened the philosophy of superabundancy and exploitation with little concern for conservation. Landowners could do almost anything they wished with their land under a governmental system that tended to give emphasis to individual rights and had a strong "laissez faire" bent in economic matters. The greatest relaxation of controls over land use occurred around 1870.

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[9] See *Statistical Abstract of the United States 1984*, pages 230-234, for data on personal consumption for recreation in 1982.

[10] Charles E. Hewett and others, *Forests in Demand* (Boston: Auburn House Publishing Company, 1982), p. 21.

Rampant exploitation of land in the Civil War era stirred a small number of visionaries like George Perkins Marsh who understood nature's life cycle and the need for conservation. In *Man and Nature*, Marsh wrote:

> The ravages committed by man subvert the relations and destroy the balance which nature had established . . . ; and she avenges herself upon the intruder by letting loose her destructive energies. . . . When the forest is gone, the great reservoir of moisture stored up in its vegetable mould is evaporated. . . . The well-wooded and humid hills are turned to ridges of dry rock . . . and . . . the whole earth, unless rescued by human art from the physical degradation to which it tends, becomes an assemblage of bald mountains, of barren, turfless hills, and of swampy and malarious plains.[11]

Most social controls took the form of laws, regulations, and governmental programs, but there have been and still are social controls that are not governmental. As examples of the latter, the early New England towns had land-use patterns that were determined socially, and today private lenders may dominate certain types of land use. The first social controls of the modern type over private land use were applied to farmland. An early and controversial social control was the use of fence laws to restrict livestock and to protect crops from livestock. Weed control laws were still another control. Under drainage-district laws a farmer's land was drained, whether he wanted it or not, and he was required to pay a share of the cost. These forms of rural land-use control were operative in various areas before 1900. Urban land-use controls came somewhat later, beginning in New York City about the time of World War I.[12]

Social controls over land use and powerful social influences short of control expanded after the depression of the 1930s and particularly since the early 1960s. For several decades controls over land use were exercised at the local level or not at all. Today most urban areas have some form of land-use regulation, but large parts of the land area outside cities are essentially unregulated. In 1963 Hawaii was the only State with land-use laws, but by 1975 California, Colorado, Delaware, Florida, Maine, Oregon, and Vermont had instituted planning controls. There are about 3,000 county governments, 18,000 municipalities, and 17,000 townships in the United States. Estimates indicate that at least 13,000 of these jurisdictions exercise some form of land-use control.

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[11] Quoted by Carl H. Madden in "Land as a Natural Resource" in the American Assembly, *The Good Earth of America* (Englewood Cliffs, N.J.: Prentice Hall, 1974), p. 19.

[12] Marion Clawson, *Man, Land, and the Forest Environment* (Seattle: University of Washington Press, 1977), pp. 3-26; Carl H. Madden, "Land as a Natural Resource" in the American Assembly, *The Good Earth of America*, pp. 6-30.

Financing for State and local land-use planning has been provided by many kinds of Federal funds. Among the several forms of Federal financial aid that have greatly affected private land use are soil conservation and farm improvement subsidies, highway funds, urban renewal expenditures, water pollution controls, flood protection expenditures, and public guarantee of private residential mortgages. Federal environmental protection laws have had some effect on private land use during the past decade, and this application will likely broaden. Tax laws at the various levels of government have an increasing effect on land use.

The case for social control over private land use rests on somewhat overlapping considerations: externalities, interdependencies, efficiency, and environmental effects. External influences or externalities result from actions one landowner takes that extend to nearby landowners. The construction of a factory emitting unpleasant odors may have a negative effect on adjacent residences. On the other hand, positive improvement by a landowner can enhance the value of a nearby tract. The concept of externalities may be broadened to include interdependencies that more realistically consider reciprocal value flows. The efficiency factor is illustrated in the development of various community services. For example, the laying of a sewer line into a community improves efficiency, but it requires the occupiers of land in the area to make use of the facility. The argument for environmental effects includes to a substantial degree, but not wholly, the factors included in external and interdependent considerations. The dumping of wastes into streams or the air may be forbidden because of damages to others (externalities) or on the grounds of environmental protection.[13]

The long-term trend has been toward much stricter zoning laws and land-use ordinances. Proposals for national land-use legislation, earlier ignored by Congress, aroused interest in that body in the 1970s; however, because of the strong current against Federal involvement in what are basically local land-use problems, legislation was not enacted on land-use planning. The trend is toward greater social controls over private land use through State and local actions.

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[13] Robert G. Healy, "Land Use and the States," *Current History 70* (January 1976): 9-14 and Clawson, *Man, Land, and the Forest Environment*, pp. 8-12.

FEDERAL LAND CONTROLS

The Bureau of Land Management (BLM) was formed in 1946 to serve as custodial manager of the public lands. A part of the Department of the Interior, it has continued to perform this function to the present time. Congress established a temporary process for receiving public lands, in the historical process of transferring public lands to private ownership, in the Classification and Multiple Use Act of 1964. In the same year Congress created the Public Land Review Commission to study public land issues. The Federal Land Policy and Management Act (Public Law 94-579), reflecting in part the Review Commission's recommendations, became law on 22 October 1976. For the first time the authority for management of millions of acres of public land was consolidated in a single statute. The Department of the Interior controls approximately two-thirds of Federal lands, totaling some 700 million acres.

A number of policy issues relating to public lands have gained public attention. Some continue to be debated, frequently with conservation-oriented interest groups on one side and those who seek, or would permit, greater exploitation on the other side. Included in the policy issues are:

–How much of the Federal land should be disposed of?

–If private use is permitted for exploitation purposes, under what terms should it be granted?

–How much effort and how many Federal dollars should be spent to conserve or preserve Federal lands?

–What should be the relationship between the Federal, State, and local governments in the management of Federal lands and in the sharing of revenues from them?

–How should planning for Federal lands be carried on?

By early 1985 the Bureau of Land Management (BLM) had reclassified 200 million areas of previously protected Federal land, done under provisions of the Federal Land Policy and Management Act of 1976. This action, which occurred primarily during the presidency of Ronald F. Reagan, opened up some 30 million acres to mining and mineral exploration. The reclassified 200 million acres is equivalent to an area approximating the States of Texas and New York, and the 30 million acres opened up for mining and exploration is about the size of the State of New York. In early 1985 the reclassification actions by BLM were challenged by the National Wildlife Federation, the Nation's largest conservation group; they claimed that the BLM acted on its own without review by the President, the Congress, or the public. The Wildlife Federation lawyers said that the BLM did the reclassification under policies developed during the tenure of Interior Secretary James G. Watt. It was claimed that Watt sought to provide private industry with broad and quick access to resources on public lands as a means to spur the Nation's economy and enhance national security. Conservationists at that time contended that national resources were being given away without concern for the environment.[14]

Director of the BLM, Robert F. Burford, defended the Bureau's actions claiming that classifications were revoked because they were not needed. The mining industry was generally pleased with the BLM reclassifications, claiming that such action should have been taken a long time ago and that it updated public land uses. The controversy over use and protection of Federal lands continues and is not likely to be settled soon.

This chapter indicates that the United States continues to have a plentiful supply of land to fill all types of needs. As population increases and the trend toward living in cities and their suburbs grows, there is increased competition for certain land. Location and use factors are primary determinants of value and price rather than quality of the soil. While there is much good cropland and forest land, there has been a temptation to exploit these areas for current profits. For decades, public-minded conservationists have been trying to educate the public to the need for wise use and conservation of land and forest resources. Pollution of both land areas and water by chemicals and other substances has increased. The work of environmentalists and conservationists has become increasingly important.

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[14] *New York Times*, April 24, 1985, pp. A-1 and B-11.

III

WATER RESOURCES

Water is not only one of the resources required to sustain individual life, but it is also fundamental to the achievement of society's goals. Nature has been particularly beneficent in providing adequate water to most of the regions of the United States. For the conterminous States the average annual precipitation is 30 inches, or for each American, some 20,000 gallons a day. The precipitation as rain, snow, sleet, or hail is reasonably well distributed by season, and most is retained in the soil, is used, or evaporates rather than reaching the sea.[1]

The abundance of high quality water, which prevailed until about the middle of the 20th century, made water a generally inexpensive commodity and tended to cause Americans to use water as if the resources were inexhaustible. Streams, lakes, and other bodies of water were frequently used for household and industrial waste disposal with no concern that the effects of such actions could destroy, or at least deteriorate, the water supply. During recent decades, however, and particularly since the mid-1960s, there has been a growing realization that the quality of the Nation's surface and ground water supplies has been deteriorating, and that this valuable resource must be protected from overuse and misuse. As with most other resources, the rate of use and competing demands for water increase in the United States as the population expands, the society becomes more urbanized, and the standard of living rises.

The demand for water in the United States has grown rapidly and this trend will likely continue. (*table 1*) This growth has begun to impose a strain on the water resources of some regions, particularly the West with its growing cities and vast irrigation needs. The average per capita use of freshwater nationwide is about 1,600 gallons per day. Not surprisingly, Idaho with its extensive irrigation consumes the Nation's high of 19,000 gallons daily per person, while Rhode Island with its ample rainfall uses the Nation's low of 180 gallons.

While overall daily use of water has increased, the rate of increase slowed from 12 percent during the 1970-1975 period to 8 percent in

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[1] Most of the data in this chapter on water supply and use are taken from U.S. Department of the Interior, Geological Survey publications, in particular, U.S. Geological Survey, *Estimated Use of Water in the United States in 1975*, Geological Survey Circular 765 (Arlington, Va.: U.S. Geological Survey, 1977) and its 1983 revision, Circular 1001. This publication includes a useful selected bibliography at pp. 15-17.

TABLE 1. ESTIMATED WATER USE IN THE UNITED STATES AT 5-YEAR INTERVALS, 1950-1980

	Estimated water use in billion gallons per day							% increase (+) or decrease (−)	
	1950[1]	1955[1]	1960[2]	1965[2]	1970[3]	1975[4]	1980[4]	1970-75	1975-80
Population, in millions	150.7	164.0	179.3	193.8	205.9	[5]216.4	229.6	+ 5	+ 6
Offstream use:									
Total withdrawals	[5]180	240	270	310	370	420	450	+ 12	+ 8
Public supply	14	17	21	24	27	29	34	+ 8	+ 15
Rural domestic and livestock	3.6	3.6	3.6	4.0	4.5	4.9	5.6	+ 10	+ 14
Irrigation	[5]89	110	110	120	130	140	150	+ 11	+ 7
Self-supplied industrial:									
Thermoelectric power use	40	72	100	130	170	200	210	+ 18	+ 9
Other industrial use	37	39	38	46	47	45	45	− 6	+ 1
Source of withdrawals:									
Ground water:									
Fresh	34	47	50	60	68	82	88	+ 22	+ 7
Saline	(6)	.6	.4	.5	1	1	.9	− 6	− 5
Surface water:									
Fresh	[5]140	180	190	210	250	260	290	+ 5	+ 10
Saline	10	18	31	43	53	69	71	+ 31	+ 2
Reclaimed sewage	(6)	.2	[5].6	.7	.5	.5	.5	+ 2	− 11
Consumptive use	(6)	(6)	61	77	[7]87	[7]96	[7]100	+ 10	+ 7
Instream use:									
Hydroelectric power	1,100	1,500	2,000	2,300	2,800	3,300	3,300	+ 21	− 2

[1] 48 States and District of Columbia.
[2] 50 States and District of Columbia.
[3] 50 States, District of Columbia, and Puerto Rico.
[4] 50 States, District of Columbia, Puerto Rico, and Virgin Islands.
[5] Corrected from published report.
[6] Data not available.
[7] Fresh water only.

Source: U.S. Geological Survey Circular 1001 (Washington: Government Printing Office, 1983), p. 47.

the 1975-1980 period. The drop is thought to have been caused by a decline in the economy, regional droughts that restricted water use, more extensive reuse of water, and perhaps the improvements in the accuracy of U.S. Geological Survey Estimates.[2]

In spite of the slowdown in demand for freshwater, interest in not only water supply but also pollution controls and preservation of water quality is growing in Congress and among policymakers. The necessity for tradeoffs between water quality and other factors involved in economic activity and preservation of the environment has given rise to controversy in writing clean water rules.

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[2] As stated by Wayne B. Solley, hydrologist at the U.S. Geological Survey National Center, in a Department of the Interior news release of March 10, 1983.

SUPPLY OF WATER

Water is a renewable resource and, therefore, the overall supply for the United States has remained relatively constant. As a worldwide phenomenon, water supply is renewed by the continuous movement of water from the oceans, to the atmosphere, to the land, and then back to the ocean. This hydrologic cycle includes evaporation of the water from the ocean into the atmosphere, precipitation onto the land, and then the flow back to the oceans. Less than 1 percent of the earth's total water supply is stored in lakes, rivers, as soil moisture, or in aquifers (underground layers of porous rock containing water). Because it is either salty or locked up in polar ice caps, over 99 percent of the earth's vast water resources are of limited use to mankind. The world's overall water supply—some 326 million cubic miles of water throughout the land, air, and oceans—has essentially neither diminished nor increased since the earth's atmosphere was formed.

Precipitation for the Nation is equivalent to 4,200 billion gallons per day. About 70 percent of precipitation is not available for use because of losses through evaporation or in movement. The remaining 30 percent constitutes the Nation's average natural runoff of about 9 inches. Annual rainfall varies, ranging from 100 inches in the coastal region of the Pacific Northwest to less than 4 inches in parts of the Southwest. The annual water runoff, the renewable supply, does not change much overall. The average annual streamflow is about three times the 450 billion gallons per day (bgd) withdrawn by all users. In addition, U.S. ground water reserves equal about 30 years of runoff.

Streamflow provides most of the Nation's usable freshwater resources, supplying about two-thirds of the water withdrawn for use. Average annual runoff exceeds 10 inches in the one-third of the country that is considered humid, and it is less than 1 inch in the third of the country considered arid. In general, the areas of least variability are in the Southwest and the north-central parts of the conterminous States. Unfortunately, some of the country's most important materials reserves are in the regions having sparse water supplies. Even in areas of high precipitation and runoff, a series of dry years may occur and result in serious drought problems such as occurred in the Northeast from 1961 to 1966.

Floods caused by excessive rainfall, melting snow, or ice jams result in loss of water and frequently inflict damage on the environment and property as well as loss of life. Annual flood damage in the United States has been estimated to average more than $1 billion, and despite the considerable flood control measures that have been instituted, it continues to increase. Damaging floods occur in many regions of the country, but parts of the Mississippi River system are the most susceptible and experience flooding most frequently. Also, portions of the Intermountain West are vulnerable to flooding from sudden spring thaws of mountain snowpack, a problem that was especially severe in Utah in 1983 and 1984. Among the measures that can be used to mitigate flood damage are the construction of reservoirs, levees, and bypasses, and the regulation of flood plain use to limit development and thus reduce the potential for damage. Flood forecasting and warning techniques have been improved and have been used extensively to reduce losses in major inundations, but flashfloods in small drainage basins are difficult to predict, and they continue to inflict damage.

Alaskan water resources are extensive and impressive. The average natural runoff is estimated to be 580 billion gallons per day and an additional 130 billion gallons per day enters from Canada. In general, the available supplies greatly exceed the projected demands, and the area will have a water surplus for many years except in local areas of intensive development. Water and related land resources form an important part of Alaska's scenic attraction and recreation potential. They support large populations of migratory waterfowl and other game species and prime commercial and sport fisheries.

In Hawaii water resources appear to be ample for all present and future needs. To provide for future water requirements, it is essential that overdraft and quality deterioration of Oahu's basal aquifer be prevented, that leakage be minimized, and that adequate recharging be assured. Other major emerging problems relate to the development of adequate water supplies for expansion of existing resort areas and for the establishment of new resort areas outside of high-density Waikiki; moreover, they relate to the development of irrigation water supplies for new croplands required to maintain present and anticipated production levels. Watershed protection and management, flood prevention, and flood control measures, important generally, are particularly significant in resort areas located near streambeds and natural drainage channels.

For the conterminous States it is estimated that the volume of water in the upper half mile of the earth's crust exceeds by more than six times the capacity of all the major lakes on the North American continent. Water pumped from most major aquifers is of relatively high quality and, unlike surface supply, is not subject to rapid fluctuations in quantity. Not all ground water is of adequate quality for use, however, and treatment may be so costly that its withdrawal is not economically justifiable. Although in some areas pumping exceeds the natural recharge, on a national basis the vast deposits of ground water are a potential that will be available for exploitation in the future. Ground water may also contribute to streamflow and give it a continuity and level of flow that it otherwise would not have.

Research and development over the past several years have advanced desalting technology to the point where approximately 350 major plants are in use. With the growing demand for good quality water, the recent trend has been to clean up the slightly salty "brackish" water that is available in many populated areas.[3] Because processes have not yet been developed to purify vast quantities of ocean water economically, development activities have slowed somewhat. Most of the existing desalting plants have been built as part of an industrial operation, but a growing number of communities are installing plants to provide drinking water.

The most popular desalting process involves the flow of brackish water through a membrane that removes salt and other impurities. Of the municipal desalinization plants in operation only the one at Key West, Florida, uses a distillation method; the others use some variation of the membrane process. All the current methods use large amounts of energy and as the costs of energy are expected to continue to rise, so will the costs of desalting water.

The Yuma, Arizona, plant is designed to desalt some 95 million gallons of brackish water each day and is considered to be the key to a long-range plan to supply Colorado River water fresh enough for agricultural use. In late 1977 several major companies, vying for contracts for the Yuma project, offered various advanced technologies with attention focused primarily on improved membrane desalting processes.

The atmosphere holds much more moisture than is naturally released in the form of precipitation, and more than 37,000 billion gallons of moisture pass over the United States each day without falling to the earth. It is this vast potential source of water that atmospheric scientists hope to manage through weather modification. To date, experiments with cloud seeding have been sufficiently successful to give reason for optimism for its potential. There is considerable evidence that under certain meteorological conditions a 10 to 20 percent increase in precipitation yield is possible over areas as large as 1,000 square miles. Because the possible increase for a given area is related to the characteristics of that particular area, extensive research and development will be needed before present techniques can be used to substantially increase the available supply of water. Other opportunities for augmenting runoff supplies are through watershed management, snowpack management, evaporation suppression, and the reduction of transpiration through vegetative manipulation.

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[3] Water with more than 1,000 milligrams of dissolved solids per liter is classified as "saline," irrespective of the minerals present, by the U.S. Geological Survey.

Transfer of water from one watershed basin to another is a common means of augmenting supplies in areas where local supplies are not adequate to meet needs. For example, part of New York City's water supply comes from the Delaware River Basin and part of Denver's supply is brought across the Continental Divide from the Colorado River Basin. Proposals for physical transfers of water from one watershed to another abound. Many of the large projects are costly and probably will have to wait until present water sources shrink to the point where interbasin transfer becomes a necessity.

USES OF WATER

Water use is the amount of water withdrawn from its sources and is equivalent to the terms "intake" or "water requirement" sometimes used. Most of our activities require the use of water; some require large quantities, but the amount needed to sustain us is relatively small. Water uses may be divided into two broad categories: the first, offstream use, includes those that remove water from its source, for example, irrigation, industrial processing, and household water services; the second category, instream use, involves instream water, for example, propagation of fish and wildlife, and most hydroelectric power generation. Some uses may fall into both categories.[4]

Offstream water use in the United States in 1980 was estimated to average 450 billion gallons per day (bgd) of fresh and salinewater. This is an 8 percent increase from the 1975 Geological Survey estimate and a 22 percent increase from the 1970 estimate. Table 1 shows the overall increase in offstream water use from 1950 to 1980, as well as a steady climb in instream use until a leveling off occurred in the use of water for hydroelectric power in the 1975-1980 period.

The general slackening in the rate of increase for most water use categories from 1970 to 1975 continued through the next 5 years, 1975 to 1980. (*table 1*) Two exceptions to this trend were public supply and rural withdrawals, increasing 15 and 14 percent respectively. Part of the public supply increase came about through a change in the listing, with 2 bgd of self-supplied industrial withdrawals being transferred to the public supply category. Rural withdrawals grew because of the increase in the population receiving water from self-supplied systems and an increase in per capita use.

The more important changes in water withdrawals and water consumed from 1950 to 1980, illustrated in table 1, can be attributed to several factors. First, the deleterious effect on the economy caused by the 1973 oil embargo had a braking effect on water use. Second, users of water, especially irrigators, have become more selective and efficient with their use of ground water, because rate of demand influences the pumping life, flow rate, and quality of the water supply—all factors that influence water cost. Third, a continually growing demand on a finite quantity of a commodity builds up stresses, including economic—the law of supply and demand. The effect of cost increases influences the quantities and alternative options of water use and may determine the point at which wastewater reuse becomes cost effective. Last, availability of water in a particular year, especially streamflow, strongly affects the quantity of water used for irrigation and hydroelectric power development.

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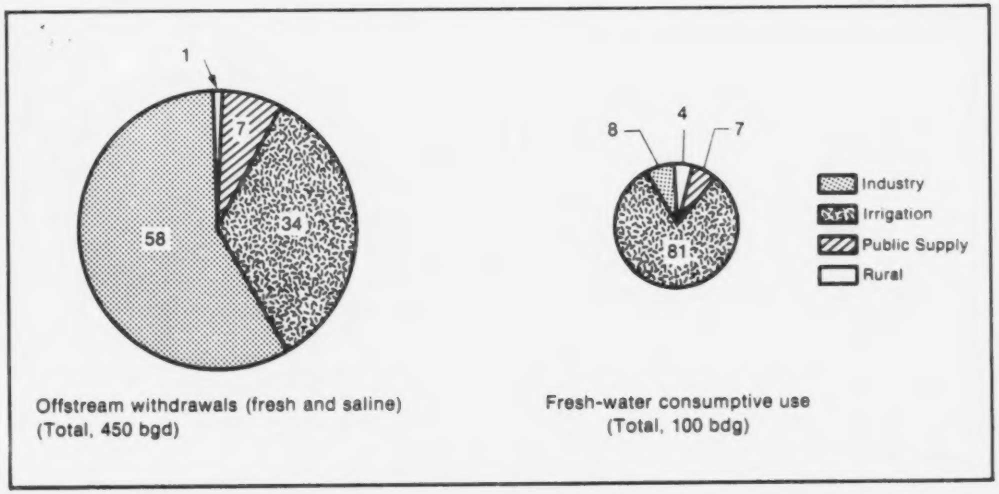
[4] The major source of data in this section is U.S. Geological Survey, *Estimated Use of Water in the United States in 1980*, U.S. Geological Survey Circular 1001 (Arlington, Va.: U.S. Geological Survey, 1983).

The percentages of water used of total water withdrawn and of freshwater consumed in 1980 by various categories of users are given in figure 2. The large percentage of total water withdrawal used by industry is illustrated graphically in the diagrams, as is the very large percentage of freshwater consumed for irrigation purposes.

California withdrew 54 bgd for offstream use, the highest in the Nation and more than twice the amounts withdrawn by Florida and Texas, the next biggest users. The California and Mid-Atlantic regions accounted for nearly a quarter of U.S. water withdrawals. Offstream withdrawals in the eastern water resources regions, which include the Mississippi River and the Souris River (in North Dakota and Minnesota), accounted for 55 percent of the Nation's total withdrawals. Freshwater consumptive use accounted for 8 percent of total eastern withdrawals and represented only 19 percent of the national total consumptive use of 100 bgd. In contrast, consumptive use in the western water resources regions accounted for 41 percent of western withdrawals. Consumptive use is defined as water that is no longer available because it has been evaporated, transpired, incorporated into products or crops, consumed by man or livestock, or otherwise removed from the water environment. The West's greater consumptive use is attributable to the fact that 91 percent of the total water withdrawn for irrigation occurred in the West, and irrigation represents the largest category of water consumed there.

Federal control of water use drew national attention in 1977, when President Carter attempted to cut funding for major water supply projects he judged unnecessary or wasteful. His efforts, sharply affecting western landowners who had traditionally received cheap water for irrigation under the Reclamation Act of 1902, brought widespread howls of protest. Some of the most vocal opponents were large corporations owning as much as 100,000 acres, well in excess of the 160-acre size limit for Federal irrigation subsidies, or 300 for husband and wife as



Offstream withdrawals (fresh and saline)
(Total, 450 bgd)

Fresh-water consumptive use
(Total, 100 bdg)

FIGURE 2. PERCENTAGE OF TOTAL OFFSTREAM WITHDRAWALS AND FRESH-WATER CONSUMPTIVE USE, BY CATEGORIES OF USE, 1980.

SOURCE: U.S. Geological Survey, *Estimated Use of Water in the United States in 1980* (Arlington, Va.: U.S. Geological Survey, 1983), p. 33.

joint owners, that was outined in the 1902 act. A bitter contest ensued and Carter's moves were blocked when a court ruling stated that an environmental impact statement had to be prepared before any new reclamation regulations would be enforced.

Scarcity of Federal funds has been a key issue in resolving the Nation's water problems. While the flow of Federal dollars for water projects has not been entirely cut off, most of the available money is being used to maintain projects already in existence and to complete projects currently under construction.

Shortage of funds continues to stir the debate on how much the Federal Government should pay of the cost of each project, and how much should come from State and local sources. A comprehensive cost-sharing policy proposed to the White House by former Interior Secretary James G. Watt, and embraced for a time by the Reagan Administration, called for: 100 percent non-Federal financing of hydropower and of both municipal and industrial water supply, 50 percent non-Federal funding for recreation, and 35 percent non-Federal funding for flood control and irrigation. This approach would have virtually reversed the traditional funding balance from mostly Federal to mostly non-Federal.[5]

The Reagan Administration seemed to be wading into the same political hot water as did the Carter Administration in 1977. A group of western Republicans in a letter to President Reagan in April 1983 warned that his support of the cost-sharing proposal would be perceived as "anti-water" and "anti-West" during the 1984 campaign.[6]

President Reagan in January 1984 soothed critics of the controversial cost-sharing plan by rejecting any fixed formula to split the cost of dams, locks, and other water projects between the Federal Government and local governments or users. The denouncement encouraged beneficiaries of the existing fund-sharing arrangement, which varies from program to program and from agency to agency, but alienated advocates of water reform and fiscal austerity

President Reagan's disavowal of a fixed cost-sharing formula probably was a trouble sign for proposed complex packages that were being debated in the Senate and House for many months and that would comprise the first omnibus water projects bill since 1976. At a cost of $11 billion, the Senate water projects bill was more modest than the $18 billion House version. Yet, it would still affect most sections of the country and deal with port development, water supply, inland waterways, flood control, protection of shorelines, fish and wildlife management, and elimination of more than 300 projects with cumulative outlays estimated at $17 billion by fiscal year 1996. Also, the bill would replace the Water Resources Council, abolished soon after President Reagan took office, with a National Board on Water Resources Policy.

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[5] Joseph A. Davis, "Water Projects Await Funding As Debate Over Cost Sharing Stalls Action on Capitol Hill," *Congressional Quarterly Weekly Report*, July 30, 1983, p. 1553.

[6] Joseph A. Davis, "Reagan Rejects Fixed Formula For Water Project Cost Sharing," *Congressional Quarterly Weekly Report*, January 28, 1984, p. 143.

CONTROL OF WATER POLLUTION

The mass-production, mass-consumption economy of the past 50 years has exacted a high price in the deteriorating quality of the Nation's water resources. Uncontrolled waste disposal, pollution from urban, agricultural, and mining developments, and the effects of erosion have heavily damaged rivers, lakes, and coastal waters. Moreover, acid rain, a term for precipitation carrying industrial emissions from automobiles, powerplants, and smelters that have been accumulated in the atmosphere and transported hundreds of miles by the wind have caused as much as $5 billion in damage annually in the northeastern United States and southeastern Canada. In addition to killing trees and damaging crops, acid rain is a major source of pollution in rivers and lakes.

The increasing demands for high-quality water[7] and the high costs for developing major new supplies of freshwater indicate increased reuse of existing water supplies in the future. Conservation and reuse must be emphasized because the Nation can no longer rely on "underpriced" water, "free" waste disposal, and "cheap" raw materials to achieve its national goals.

Public concern for pollution caused increased Federal action in the 1950s, and the first comprehensive antipollution measure, the Federal Water Pollution Control Act, was passed in 1956. This act provided financial assistance to State and interstate agencies, grants for the construction of municipal sewage-treatment facilities, and the legal basis for Federal action to prevent pollution of interstate waters. In the next few years antipollution efforts gained strength and public interest broadened. Congress furthered the Federal antipollution program with the Water Quality Act of 1965, which established a basis for quality standards for interstate waters and the enforcement of standards already set. Congress also, through passage of the Water Resources Planning Act of 1965, established the U.S. Water Resources Council to assess the adequacy of water supplies and to propose national policies. In the Clean Water Restoration Act of 1966 Congress gave additional incentive to the development of plans for control and abatement of river pollution. The latter act also liberalized Federal construction grants for municipal waste-treatment plants. Both the Water Quality Act and the Clean Water Restoration Act were principally concerned with establishment of conventional waste-treatment facilities. Generally speaking, however, the Federal grant programs under these acts failed to achieve the anticipated improvement objectives in the 1960s.

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[7] In its 1973 report the National Water Commission expressed its opinion that 500 parts per million of dissolved solids should be the recommended allowable concentration for municipal water supplies. There are other characteristics by which water quality may be judged, however, and authorities are frequently not in agreement on tolerance levels. For example, 4 milligrams of dissolved oxygen per liter is often considered to be a desirable level, but some authorities prefer 6 milligrams per liter, and still others believe 1 milligram per liter is enough in some circumstances.

The efforts to study water resources and to obtain data for water policies moved ahead with the 1968 report of the Water Resources Council's assessment. In that same year, Congress established a seven-member commission, whose members were from outside the Federal Government, to make a 5-year study of water problems and to recommend policy changes to the President and the Congress. This commission, the National Water Commission, made interim reports in 1970, 1971, and 1972 and submitted its final report, *Water Policies for the Future,* in June 1973. In the course of its work the commission examined virtually the entire range of water resource problems facing the country, and in its final report made hundreds of recommendations (many of them relating to the improvement of water quality) for action at the Federal, State, and local levels.

The Federal Water Pollution Control Act amendments of 1972, now known as the Clean Water Act, began an effort to control pollution at the point of discharge, rather than through a subjective judgment of how much pollution a waterway can assimilate. The act stands as a Federal commitment to protect the integrity of the Nation's waters by motivating industry to reuse, recycle, and contain chemical wastes. The act calls for maintaining a level of cleanliness in rivers and lakes that allows for aquatic life, fishing, and swimming.[8] Yet, these ideals, fashioned over a decade ago, are not being fully met. More than $37 billion has been appropriated by the Federal Government and $16 billion from industry since 1972 to battle sewage problems. Although some 4,000 treatment plants have been built or improved, an estimated $228 billion in government and private funds will be needed by the end of the century to reach the standards envisioned. As of the 1 July 1983 deadline, many localities had failed to attain swimmable, fishable waters. Moreover, costs of cleanup are rising.

The Act of 1972 set as a national goal the elimination of all pollutant discharges into national bodies of water by 1985. The National Water Commission, however, considered the objective of "zero discharge" as "an impractical and unattainable goal."[9] Benefits from water pollution controls are subject to severely diminishing returns as the standard set by the 1972 act is approached. The last 1 percent of pollution, according to data compiled by the commission, involves doubling the staggering costs of eliminating the first 99 percent. In the opinion of the commission, "the adverse impacts on land and air may be far more damaging to the environment than the retention of the last 1 percent of water pollution, particularly in areas where the self-purifying capacity of water is great or where other uses of water are not adversely affected."

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[8] James T. Banks and Frances Dubrowski, "Clean Water: Act III," *The Amicus Journal* 3 (Spring 1982): 33-36.

[9] National Water Commission, *New Directions in U.S. Water Policy* (Washington: Government Printing Office, 1973), p. 38.

To achieve the goals established in the 1972 act all U.S. industries were required by July 1977 to use the "best practical control technology currently available." Municipal waste-treatment plants were directed to provide secondary treatment, removing 85 percent of pollutants by 1 July 1977. Requirements set up in the law were to be enforced through a pollutant-discharge-permit system based on effluent guidelines established by the Environmental Protection Agency (EPA) for the various industrial polluters.

Progress in carrying out the 1972 Pollution Control Act was hampered by the fuel crisis that developed in late 1973 and by other causes. Construction of municipal plants was delayed through 1975 by the slow release of Federal construction grant funds. The Nixon Administration impounded $18 billion, which was not released until early 1975 when the Supreme Court ruled the impoundment illegal. Also, bureaucratic red tape and lack of expertise at the local level hampered the municipal construction programs. The Administrator of the Environmental Protection Agency reported in February 1976 that the agency had issued permits for most major pollution sources. He also stated the vast majority of industrial permitholders would have the technology called for by the 1977 deadline while only half of the municipal plants would have secondary treatment facilities by then.

On 18 March 1976 the National Commission on Water Quality sent Congress a report recommending modification to the ambitious and costly 1972 water pollution control law. The commission, chaired by Vice President Nelson A. Rockefeller, included five Senators, five Congressmen, and four public members. Several of the Congressmen filed separate views questioning some of the recommendations. The strongest dissent came from Senator Edmund S. Muskie, a chief author of the 1972 legislation. In the report the commission asked Congress to extend the 1977 pollutant-treatment requirements on a case-by-case basis; postpone the 1983 "best available treatment" requirement for 5 to 10 years; authorize state certification for pollution-abatement planning and administration as a step toward decentralization; provide $5 to $10 billion in construction grant funds for a period not exceeding 10 years at the 75 percent matching level; and redefine the 1985 "zero discharge" goal, stressing conservation and reuse while striving to achieve good quality water. In his separate statement, Vice President Rockefeller maintained that the proposed changes would retain the regulatory mechanism of the 1972 law while Senator Muskie, in a separate opinion, stated the recommendations, in effect, would require repeal of the regulatory mechanism adopted in 1972.[10]

Controversy arose during congressional efforts to work out pollution control amendments in 1976 and 1977, and it was not until December 1977 that contending forces in Congress came to agreement. On 27 December the Clean Water Act of 1977 (PL 95-217) was signed into law. The amendments, containing nearly 80 separate provisions, modified the 1972 Pollution Control Act, in some cases extending deadlines and in others easing the rules. The final compromises to gain agreement in the Congress did not give a clear victory to either the industrialists who sought relaxation of the 1972 rules or the environmentalists who fought for upholding pollution controls. Senator Muskie was of the opinion the amendments preserved the objectives of the 1972 law by providing adequate enforcement tools for the Environmental Protection Agency and by including the flexibility needed to meet the most serious problems on a priority basis.

The kinds of modifications that were included in the 1977 amendments are illustrated in the following examples: On a case-by-case basis, the Environmental Protection Agency could extend the deadline for industrial polluters to meet the requirements for best practicable technology from 1 April 1977 to 1 April 1979. The deadline for industry to meet the best available technology test was extended from 1983 to 1 July 1987. In other actions, major funding was provided for the Nation's sewage treatment construction program, with $4.5 billion authorized for fiscal 1978 and $5 billion authorized annually for fiscal years 1979 through 1982. The grant funding paid for 75 percent of the costs of municipal plants built to comply with clean water standards. The EPA administrator was given various authorizations to use new tools to improve the management of pollution programs and to work out improved interface with States and other jurisdictions.

A third rewrite of the Clean Water Act was begun in 1982. The effort has proven to be as controversial as the earlier two and has sparked heated debate in Congress and among environmentalists and industrialists. Some environmentalists are pleased with the emerging rewrite, still underway as of early 1985, while others view it as an effort of the Environmental Protection Agency to join "big polluters" in an attempt to dilute the 1977 overhaul of the act.[11]

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[10] *Congressional Quarterly Almanac*, 1976, pp. 170-171.

[11] Banks and Dubrowski, "Clean Water: Act III," pp. 25-40.

Critics of the rewrite charge that proposed changes would make it easier to downgrade water quality standards and destroy wetlands, immunize many industries against more stringent pollution control requirements, and grant specific exemptions to two pulp mills in Alaska and other wastewater dischargers. Among other provisions in jeopardy are several that would fund cleanup of estuaries and authorize a study of whether adding lime to lakes can counter the effects of acid rain.[12]

QUALITY OF DRINKING WATER SUPPLIES

Establishment of drinking water standards, which is closely related to pollution controls, has become a controversial issue. While industry officials appeared to be content with the manner in which the Environmental Protection Agency enforced the Drinking Water Act of 1974, environmentalists brought lawsuits charging the agency with being derelict in implementing the act. For 4 years before 1974, efforts to pass safe drinking water legislation languished in Congress. An EPA study released in November 1974 showing the poor quality of water in New Orleans and an Environmental Defense Fund Study the following month citing poor water in 11 States were important factors in passage of the Drinking Water Act. Before the 1974 enactment, the Federal Government's program for drinking water primarily related to water provided on interstate carriers and water as it concerned the spread of communicable disease.[13]

The Drinking Water Act of 1974 extended Federal authority to public and private systems that supply water at least 60 days a year to 25 people or more or have 15 or more connections. All water suppliers coming under the act were required to conform to EPA standards. The national primary standards protect health by specifying the maximum allowable level of contaminants and the frequency of monitoring. National secondary standards apply to contaminants that affect the taste, odor, or appearance of drinking water but not its safety. States are primarily responsible for supervising water systems and enforcing the EPA standards. When the agency determines that a State does not have the ability to enforce the standards, then it must assume the task. A 15-member National Drinking Water Advisory Council was created to provide advice to the agency in drafting standards and regulations under the 1974 Act.

The reluctance of the Environmental Protection Agency to set definitive standards aroused the wrath of many environmentalists. The agency maintained that it needed more data and information on the harmful effects of contaminants even after a December 1975 study showed that drinking supplies in 80 cities contained at least 253 organic compounds, several of which were suspected carcinogens (cancer-causing substances). Chloroform, a known carcinogen for animals, was found in varying concentrations in every one of the drinking water supplies of the 80 cities. The assessment of the significance to health of particular levels of carcinogens poses a most difficult problem for the Environmental Protection Agency. The Environmental Defense Fund, a public interest group, proposed that the agency require the largest utilities to place fresh or activated carbon in their filters to replace sand, a method the agency has considered best for removing environmental organic contaminants. Several of the States have contended that the costs of using carbon would be staggering, but EPA estimates indicate the costs to large utilities would add only from $4 to $7 a year to the water bill of a family of four.

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[12] "Rough Sailing Ahead for Clean Water Bill," *Congressional Quarterly*, June 9, 1984, p. 1387.

[13] Arthur J. Magida, "Implementing the Drinking Water Act," *National Journal* (June 12, 1976): 822-824.

An overhaul of the Safe Drinking Water Act was underway as of early 1985. The rewrite would set deadlines for the Environmental Protection Agency to regulate contaminants in drinking water, increase funding for Federal safe drinking water programs, and make tampering or threatening to tamper with a public water system a Federal crime. Negotiators agreed to omit from the final bill the ambitious underground water plan that had drawn fire from the Reagan Administration and a number of members of the Senate Environment and Public Works Committee. As the 98th Congress neared its end, however, the future of the rewrite remained uncertain.[14]

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[14] "Safe Drinking Water Bill Ready for House Floor," *Congressional Quarterly* 42, September 15, 1984, p. 2236.

IV

AGRICULTURE AND FOOD

The United States is generously endowed with land that can be put to agricultural use. American farmers have traditionally produced surpluses for export, while they have amply fed the American people. We have a virtual cornucopia of agricultural products, and our citizens are among the best fed in the world. In general, Americans have over 3,400 calories available per day, and their diet contains plentiful quantities of meat and a wide variety of fresh seafoods, vegetables, fruits, dairy products, and processed foods. Yet, for all this abundance, families in the United States pay less than 15 percent of their incomes for food, which is the smallest percentage of any country in the world.

In addition to providing for our own people, the American farmer has gained a well deserved reputation for a capability to produce surpluses for export. We are the largest producer of agricultural products for export, and we provide foodstuffs to both advanced and developing nations. The developing countries continue to be collectively the leading commercial outlet for U.S. farm exports, but our largest individual trading partners are the advanced industrial nations. For example, in 1984 approximately 40 percent of our food production went overseas; Japan imported the largest amount, valued at $6.9 billion. After Japan, the importers of our food production by amount were: the U.S.S.R., the Netherlands, Canada, South Korea, Taiwan, and West Germany. Agricultural exports accounted for 20 percent of all U.S. exports, and a positive annual agricultural trade balance averaging $38 billion helped offset the overall 1984 U.S. trade deficit of $101.6 billion.[1]

Our agricultural exports include 59 percent of our wheat, 41 percent of our feed grains, 87 percent of our cotton, and 72 percent of our rice. The U.S. Department of Agriculture estimates that we will need only 50 percent of our agricultural resources to feed ourselves by the year 2000.[2] However, a decline in 1985 farm exports raised the question of how we would handle new surplus accumulations. The stronger dollar made us less competitive on the world market by effectively adding 30 percent to the price foreign buyers paid for our farm goods. If this trend continues, the disposal of those surpluses at reasonable prices, and at minimal cost to the taxpayers, will pose another in a growing number of farm problems for our national policymakers.

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[1] U.S. Department of Agriculture, *Foreign Agricultural Trade of the United States*, November/December 1984 (Washington: Government Printing Office, 1984), p. 7.

[2] *Washington Post*, April 8, 1985, p. A 5.

With the help of developments in mechanization, chemical fertilizers, hybrids, and pesticides, the American farmer has made an enviable record in both productivity and increasing output. Our farmers are models of efficiency—their output per hour of work grew 4.4 percent a year during the past decade, and this increase is more than six times the rate of growth among nonfarm businesses. In 1972, one farmer produced food for 53 persons, while today it is 78.[3] In 1930 approximately 20 hours of labor were required to produce 100 bushels of corn; in 1985, however, only 3 hours of labor were needed to produce the same amount of corn on half the acreage that was previously required. With ever expanding technology, this increased productivity will continue. But higher costs of production, coupled with environmental constraints to preserve our soil and water resources, will undoubtedly slow future rates of increase.

Despite the increases in productivity, the American farmer has not made comparable gains in personal purchasing power, and many farm residents turned to nonfarm sources for additional income. Of the total of 2.4 million farms in the United States, some 1.7 million have sales of less than $40,000 a year, and half of the 1.7 million derive most of their income from off-farm jobs. Since the late 1960s, nonfarm income has exceeded farm income for the average farm worker, and with the recent decline in farm prices, this trend will increase.[4]

THE FARMING SYSTEM

During this century, American agriculture has experienced a revolution in its productive capabilities. This change was primarily brought about by the transformation from animal to mechanical power—a change that also caused significant social and economic adjustments in rural living. The old system of cultivation, based on human and animal power, reached its peak during World War I. Up to that point, farm population, acreage, and the number of farm animals had steadily increased. During the 1920s and 1930s, farmers began the shift to mechanical power, and the farm environment began to stabilize. Then, at the beginning of World War II, farm population sharply declined, and from 1940 to 1985, the number of people on farms decreased from 30.5 million to 5.8 million. In 1940, 23 percent of America's people lived on farms, but only 2.4 percent live on them today. The number of farms has also declined over the years, from nearly 6.4 million in 1940 to 4 million in 1960 to 2.4 million at the beginning of 1985. While there has been roughly a two-thirds reduction in the total number of farms, the remaining farms have become much larger and are producing even greater quantities of food. The average size of U.S. farms in 1985 was 440 acres or about 10 percent larger than in 1977.[5] Despite this increase in size and productivity, net farm income fell from $31 billion in 1981 to an estimated $22 billion in 1985, as overproduction sent crop prices to lower levels.[6] These lower prices, combined with higher interest rates and increased operating expenses, resulted in a 30 percent reduction in net income levels from 1981 to 1985.

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[3] *U.S. News & World Report*, May 30, 1983, p. 51.

[4] *Washington Post*, January 20, 1985, p. C 4.

The trend has been for the largest farms to account for an increasing share of product sales. Of the total 2.4 million farms, there are 96,000 farms that sell over $200,000 in farm products each year and they account for half of all sales. Included in this category are 24,000 "super farms" with annual sales of over $500,000.[7] These large farms are well-financed, modernized, and businesslike in their management, while farmers on distressed smaller farms struggle to survive. For example, a farm worth $500,000 earns an average of only $10,000 a year; this income is below the 1985 established poverty line of $10,613 for a family of four.

Family farms producing 40 percent of the Nation's food continue to dominate the agricultural business with annual sales of $40,000 to $250,000. However, as these farm families face lower prices for their crops, higher interest rates, reduced land values, and rising debt, many face foreclosure. Farm bankruptcies threaten many rural banks, farm equipment firms, and the economic health of entire communities.

Family life on the farm has also undergone great change. The day of the horse and buggy, the small country store, and the closely knit community where there was interdependence among farm neighbors has given way to a modern style of living. Today, lifestyles of the typical farmer reflect the general affluence of suburbia, and some see this change as a prime cause of the mounting farm debt problem. With modern transportation, the farmer can shop and carry out social and other activities in the city; thus, the rural community or small farming town is left without any real economic or social role. The small traditional farm family, in this changing environment, has continued to be the pillar of the American farm system. Nevertheless, the current farm crisis may well result in a major shift in U.S. agriculture: life on the family farm may become an institution of the past as "super farms" expand to fill the void left by the farm family.

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[5] Ronald D. Knutson, J. B. Penn, and William T. Boehm, *Agricultural and Food Policy* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1983), p. 184.

[6] *U.S. News & World Report*, February 4, 1985, p. 48.

[7] *Washington Post*, January 20, 1985, p. C 5.

FARM INCOME AND FEDERAL SUPPORT

Farm income during most of the period since World War I has tended to lag behind earnings in the other sectors of our economy. Surpluses have also generally prevailed, and those surpluses have been the prime cause of the farmer's difficulties. For the most part, the farmer operates in an economic environment where production costs tend to rise more rapidly than agricultural prices, and many costs, such as new equipment, are fixed and not immediately related to increased output. Lower prices for farmers' crops coupled with higher interest rates as they attempt to restructure past debts make it difficult, if not impossible, for many to meet their yearly expenses out of current income. While farm assets, mainly real estate, amount to just over $1 trillion – up 61 percent since 1977 –, debts have more than doubled during this same period to total $215 billion. It costs farmers approximately $21 billion a year just to pay the interest, and many are hopelessly going deeper in debt.[8] A recent Department of Agriculture survey found that one-third of all family-sized commercial farms, owing almost half of all farm debt, will face financial difficulty in 1985, and 6.5 percent of all farms are either insolvent or on the verge of insolvency.[9] Many of these farms will go out of business because they cannot get a decent price for their crops and have exhausted their credit. Given these trends, there is agreement among many farmers, legislators, economists, and agribusiness leaders that U.S. farm policy is in serious need of revision.

In the 1920s farm income fell well below that of the other sectors of the U.S. economy, but it was not until 1933 that Federal efforts were taken to resolve the farm problem. Our governmental programs have been based from the beginning on the concept of parity – a concept that establishes a standard that gives the farmer a "fair" return to bring purchasing power to a level compatible with other U.S. workers. Generally, governmental programs have attempted to adjust output to demand at prices higher than the uncontrolled market would have produced. The main methods have been the reduction of crop acreages, support of farm prices, and placement of surpluses in storage. Although acreage was controlled, fertilizer and more efficient machinery were not, and total farm output continued to expand. Further, our subsidized conservation programs and irrigation projects increased the production capacity of some agricultural areas that would have otherwise been less productive. While the Government was trying to hold down the acreage put in crops, they were also aiding projects that increased cropland acreage and improved productivity.

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[8] *New York Times*, February 26, 1985, p. A 20.

[9] *New York Times*, March 11, 1985, p. A 15.

The Agricultural Adjustment Act of 1933 provided emergency relief to farmers and was the first real effort to deal with farm surpluses. The act provided for reductions in planted acreage of crops that had large surpluses and for compensation to farmers who withdrew acreage from production. The program was financed by a tax on processors and a devaluation of the currency. In 1933, there was a serious drop in farm prices; prices that had previously been 90 percent of the pre-World War I levels fell to only 50 percent of those levels. Desperation measures to remove surpluses led to the slaughter of livestock without making use of them and to the plowing under of crops. The press emphasized these measures, and it had a discrediting effect by highlighting only the reduction of the surplus, rather than the balanced output aspects of the New Deal programs.

An Agricultural Adjustment Administration was established in the Department of Agriculture to control the acreage reduction programs and the purchase of surpluses. To handle transactions involving surpluses and storage of agricultural stockpiles, the Commodity Credit Corporation was set up in 1933 under the Reconstruction Finance Corporation. It was later moved to the Department of Agriculture and continues its function to the present time.

The Agricultural Adjustment Act was declared unconstitutional in 1936, adjudged as being an unwarranted invasion of State jurisdiction and an improper use of the taxing power. However, new legislation, the Agricultural Adjustment Act of 1938, reenacted the basic features of the 1933 act and made the price support program permanent. Under the 1938 act, if a farmer complied with the acreage allocation, he was eligible for price support and could obtain a loan from the Commodity Credit Corporation by using the crop as collateral. At harvest time, the farmer could then sell the crop on the open market or sell it to the Commodity Credit Corporation at what was considered to be a fair return, or "parity."

The 1930s was a difficult period for farmowners; many became tenants or farm laborers, and others had to join the unemployed in the cities. In addition to low prices, widespread drought and duststorms in the Great Plains caused significant economic disruptions in the life of the farmer. The solution, given that farmers then comprised a fourth of the U.S. population, was for the Government to intervene in agricultural markets and rural life. The basic goals of the farm program were income redistribution, restoration of the farmer's purchasing power, and preservation of the Nation's resource base. There is no question that these programs have favored some farmers over others. For example, livestock farmers, who receive prices that may drop as much as 25 percent on a yearly basis, receive no subsidies. Also, large farms benefit most from payments to keep cropland out of production.[10] The New Deal programs, although criticized, costly, and initially experimental, did help the American farmer during this critical period. World War II, however, quickly changed agricultural demand, and a full recovery of the farming economy occurred during the 1940s.

While considered temporary at the time they were enacted in the 1930s, the primary elements of Federal farm policy continue to be:

—Price-support loans: supplying farmers with operating money to tide them over until they can sell their commodities. Effectively, these loans insure minimum market prices for the farmer. For example, a farmer can default on the loan, letting the Government keep the crop, if he or she is unable to get at least $3.30 a bushel for wheat—the current price-support loan rate.

—Production controls: limiting the land a farmer may plant or the amount of crops that may be sold each year. Acreage reduction has always been questionable since farmers often retire their worst land and get the maximum yield on the rest. For example, in 1983 the Government instituted a Payment-in-Kind Program that compensated farmers for idling approximately a third of the Nation's cropland. Yet, if it had not been for the confounding impact of a severe drought that year, which reduced crop levels, most analysts now believe that the program would not have stopped the continuing expansion of U.S. farm productivity. As noted by Earl Butz, Secretary of Agriculture during the Nixon Administration, "we got some swampland rented to the Federal Government. What else is new?"[11]

—Income supplements: paying farmers cash when market prices fail to reach statutory target levels. These "deficiency payments" are the difference between the lower market price and the higher target price for major crops. Payments under this program were minimal during the export boom of the 1970s but have greatly increased since market prices declined in the 1980s.

—General governmental involvement in the agricultural economy: This involvement includes the easing of antitrust barriers, public financing of agricultural storage facilities, tax breaks for rural electric and telephone service, provision of loans with favorable interest rates through the Farm Credit System and the Farmers Home Administration, a large bureaucracy of experts in agricultural research at public land-grant universities and U.S. Department of Agriculture experimental stations; and subsidized irrigation water and grazing rights on publicly owned lands.

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[10] *The Wilson Quarterly*, Summer 1981, p. 135.

[11] *Congressional Quarterly Weekly Report*, January 26, 1985, p. 139.

FOREIGN MARKETS

After World War II there was an extremely high demand for U.S. farm commodities, but dollar shortages abroad tended to limit export sales. With massive surplus stocks in our inventories, several arrangements were made for disposal, both through domestic programs and programs intended to advance U.S foreign policy and to reduce world food shortages.

One method of boosting sales was for the Government to pay subsidies to exporters to make up the difference between the world price and the domestic price. Exports for dollars were supplemented by selling farm commodities for soft currencies that could then be converted into dollars. Our products were also exchanged for soft currencies, subject to the restriction that the proceeds could only be spent in the recipient country. These credits were to be used to defray U.S. expenses, to assist the local economy through loans and grants, or to support other local purposes. Another method was that of barter, by which the U.S. exchanged agricultural products for goods needed by U.S. agencies or materials required in the national stockpile. Charitable purposes were also served, especially by donations to countries seriously deficient in food.

The Agricultural Trade Development and Assistance Act of 1954, sometimes referred to as Public Law 480, was considered to be a way to dispose of food surpluses, to develop and expand markets for U.S. agricultural products, and to support broad foreign policy goals. Because of the association of this act with efforts to share our abundance with less fortunate nations, it was designated the Food for Peace Program. Under Title I of this law, the United States lends money to countries to buy American farm products—mainly wheat, rice, cotton, tobacco, and soybeans. The loans are usually for 20 to 40 years and carry low interest rates. A minimum of 75 percent of the food allocated under Title I in any fiscal year goes to countries that meet the per capita gross national product (GNP) poverty levels set by the International Development Association; these countries must also be unable to secure sufficient food through their own production or commercial imports. Also, Title I agreements cannot be made with any country engaging in a consistent pattern of gross violations of internationally recognized human rights, unless it is determined that the aid or the proceeds from their sales will be used for programs that benefit directly the needy people of that country.

Under Title II, the United States donates food either to foreign governments or to international relief organizations such as CARE.

Some additional aid, outside of Title II, is also provided to foreign countries through the Agency for International Development in the Department of State.

Under Title III, other countries are encouraged to use the foreign currency proceeds from the sales of commodities authorized under Title I to increase food supplies, provide the poor with access to those food supplies, and improve the well-being of the rural poor. Countries participating under this title must submit annual program reports, and aid is discontinued if agreements are not being met.

One of the continuing purposes of Public Law 480 has been the promotion of foreign policy objectives of the United States, and our Government has successfully applied the program throughout the world.

FEDERAL PROGRAMS

Costs of Government programs to assist farmers have risen dramatically since the 1960s and 1970s, when they averaged $6 billion per year. In 1981, the authorized program was estimated at $11 billion, but actual costs of the 4-year program, through early 1985, are not above $50 billion.[12] Even with these ever-increasing subsidies, many of our farmers have levels of debt that mean almost certain failure given current market conditions.

Farming has become a high-capital business, and many farmers cannot earn enough from their crops to pay off their loans. The basic problem is surplus, as our farmers have produced more than global markets can absorb. During the 1970s, there was an expansion of American agriculture to serve what was then believed to be an ever-expanding international market. For example, China was considered to be an unlimited agricultural market for the United States and, 5 years ago, bought significant amounts of U.S. cotton and feed grains. Today, China is exporting these same crops. Soviet purchases of grain, once seen as an expanding market for our surpluses, have been irregular and plagued by political and consumer considerations. The grain embargoes and limitations placed on these sales have resulted in other countries filling Soviet grain requirements, and what was once seen as a positive market has now developed into a destabilizing influence on both U.S. and world grain sales.[13]

Surpluses resulting from the expansion of the 1970s have kept market prices at levels often below what it costs a farmer to grow the crops or to raise livestock. Combine this problem with falling land values,

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[12] *Congressional Quarterly Weekly Report*, January 26, 1985, p. 135.

[13] Gordon K. Douglas, *Agricultural Sustainability in a Changing World Order* (Boulder, Colo.: Westview Press, 1984), p. 136.

high levels of past indebtedness, and high interest rates; and 10 to 15 percent of our farmers cannot get the loans necessary to finance planting and to pay their expenses until harvest. The basic problem is one of long duration, and credit assistance would be only a temporary measure to keep farmers in business for the coming year. Farm prices continue to be depressed, as they have been for the past 3 to 4 years, and this will lead to another unprofitable year for those in financial distress. Even with the financial problems of many farmers, the need for credit assistance is not universal. The U.S. Department of Agriculture estimates that approximately two-thirds of our farmers have manageable debt loads or are debt-free. But if widespread bankruptcies eliminate lenders and cause markets to collapse by putting large amounts of farmland on the auction block, these otherwise stable farmers could also be endangered. If credit problems are not addressed, we will risk our agricultural banking system and a significant segment of our farm economy.

The Reagan Administration has been concerned with the high costs of price supports and related farm programs and has been reluctant to extend additional assistance to financially stressed farmers. When David A. Stockman was the Director of the Office of Management and Budget, he stated some opinions in early 1985 to the Congress: He expressed his lack of support for a credit bailout, and he proposed drastic cuts in farm program spending that would expose farmers to worldwide free market forces. Many people felt that under Mr. Stockman's proposals, distressed small farmers would be quickly attrited, and larger farms would take their place.[14] Mr. Stockman compared farmers to other small businesspeople and questioned why the Government should even be involved in the business of farming. Hundreds of thousands of businesses fail each year as market forces dictate success or failure, free of Government supports. Moreover, he expressed his belief that many farmers overextended themselves in the expanding farm climate of the 1970s, and that they should now deal with their financial situations free of Government assistance. In testimony to the Senate Budget Committee, Mr. Stockman stated: "For the life of me, I cannot figure out why the taxpayers of this country have the responsibility to go in and refinance bad debt that was willingly incurred by consenting adults."[15]

How the Government will specifically act on this volatile issue is unclear, but as Congress prepares to reauthorize the Nation's farm programs, it is obvious that changes must be made to serve the economic and political realities of the 1980s. High budget deficits and the need to compete in increasingly tough foreign markets require farm programs that are both imaginative and in the best interests of the Nation. While serious adjustments are necessary, they must be managed carefully to prevent repercussions beyond the farm problem. Many people hope that the Government will establish a middle ground that will provide essential direction to solve the crisis and will also help our farmers make the transition from the farm policies of the 1930s to those of the future.

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[14] Lawrence Dyer, *Renewing American Industry* (New York: The Free Press, a Division of Macmillan, Inc., 1983), p. 142.

[15] *Congressional Quarterly Weekly Report*, February 9, 1985, p. 279.

V

FOREST RESOURCES

The United States has always had a rich store of forestry resources, and it continues to be largely self-sufficient in wood products despite the need for increased imports in recent decades. Until World War II the United States was a net exporter of forestry products; however, since 1947 imports have exceeded exports. Over the past 35 years domestic output has accounted for roughly 90 percent of the dollar value of forest product materials consumed. Overall, apparent consumption of timber products has remained fairly constant; in millions of cubic feet in roundwood equivalent, total consumption was an estimated 11,815 in 1981 as compared to 12,995 in 1970 and 10,145 in 1960.[1] Per capita consumption of timber products had decreased from 80 cubic feet in 1950 to less than 67 cubic feet per year in 1981.[2]

The pattern of lumber prices was uneven in the 1970s, but generally the increase in the cost of lumber was higher than the average for all construction materials and the average for all commodities. The wholesale price index for selected timber products, using 1967 as equal to 100, shows that for all timber the index for 1965 was 94, for 1970 it was 114, and for 1975 it was 193.[3]

Although in recent years forests have taken on an important value for uses other than wood products, they have always been important to hold moisture and soil in place, thus preventing erosion. They have gained significantly in their use for outdoor recreation and in the preservation of wildlife. Annually the average American spends 1 day in a national forest, 1 day in a unit of the national park system, 2 days in a state park, and additional periods of time in other publicly or privately owned forest land.[4] Much of this recreational time is spent in forested areas, but not all of it.

The Nation's forests still occupy about one-third of the land, even though they have been greatly reduced since the days when the first permanent white settlers set foot on American soil. In the colonial era and the period of westward expansion, when settlers were carving out homesteads, the dense forests provided building material and fuel, but they also presented major problems—not the least of which was that they were the habitat of sometimes hostile Indians and were difficult to penetrate except on foot, making them obstacles to settlement and travel. To build a home and to make cropland, the settler had first to clear the forest on a chosen plot of ground and to dispose of the useless timber, a small portion of the amount cleared. With no market for this excess wood, it was a common practice to burn the unneeded logs in place. The pine trees of the New England forests made superb masts for British sailing ships, and a brisk logging business developed, using methods that gave little concern to selection or to preserving the trees left standing. Unfortunately, many of the wasteful practices of that time are still in use today.

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[1] Bureau of the Census, *Statistical Abstract of the United States, 1984* (Washington: Government Printing Office, 1983), p. 695. Output of timber products is measured in cubic feet, in board feet, and by weight. One board foot is equal to a piece of wood one foot long, one foot wide, and one inch thick.

[2] Ibid., p. 695.

[3] Primary sources for material in this chapter are U.S. Department of Agriculture, Forest Service, *The Outlook for Timber in the United States*, Forest Resources Report 20 (Washington: Government Printing Office, 1973); U.S. Department of Agriculture, *The Nation's Renewable Resources: An Assessment 1975*, Forest Service Report No. 21 (Washington: Government Printing Office, 1975), and Marion Clawson, *Forests For Whom and For What?* (Baltimore: Johns Hopkins University Press for Resources for the Future, Inc., 1975).

[4] Clawson, *Forests for Whom*, p. 31.

The original, or virgin, forests of the United States were generally mature growth, and the cutting and burning by settlers and lumbermen were a shock to the ecosystem. Although some forests were able to restock themselves after exploitation, the process was slow. Some people began to become concerned about forest destruction by the middle of the 19th century, but it was not until 1891 that the first forest reserves, now the National Forest System, were established. The period of most rapid expansion was from 1905 to 1909 when the acreage under Forest Service Administration rose from 75 million to 172 million acres.[5] The national forest system by 1975 had grown to 188 million acres and still another 38 million acres, including publicly and privately owned land, was included within national forest boundaries.

Since 1900 the total acreage of land in forest has been relatively stable. This was not so in terms of timber inventory, however, because until World War II the harvesting of mature or virgin stands of trees went on at a faster pace than did annual growth. The low point in timber inventory was probably reached in the early 1940s. In recent decades the condition of timberlands has improved materially, primarily because of expanding fire protection, some increase in tree planting, and other beneficial forestry activities. As a result, net growth of both softwoods and hardwoods increased about one-third between 1952 and 1970 to a total of 10.7 billion cubic feet of softwoods and 7.9 billion cubic feet of hardwoods.[6]

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[5] U.S. Department of Commerce, *Historical Statistics of the United States: Colonial Times to 1957* (Washington: Government Printing Office, 1960), p. 310.

[6] Forestry Service, *Outlook for Timber in the United States*, p. 1.

FOREST LAND

Some 737 million acres, or about one-third of the 2.3 billion acres of land in the United States, were classified as forest lands in 1977. The quality of forest areas varies widely. Two-thirds of the Nation's forest land in 1970, or 500 million acres, was classed as commercial timberland area capable of growing at least 20 cubic feet per acre of timber per year and suitable now or prospectively for timber harvesting. The remaining one-third of forest land – some 229 million acres – is reserved for parks or other purposes, or its productivity is too low for economical wood production. A broad variety of woodland plantlife is found in the poor areas, including woodland grass, chaparral, pinyon-juniper, and subalpine forests. Much of the forest in the interior of Alaska is a part of this acreage.

Nearly three-fourths of the commercial timberland is located in the eastern half of the United States. Forests cover 80 percent of New England, and more than one-half of the area along the Atlantic Coast. The one-fourth of the Nation's commercial forest located in the West is concentrated in the Pacific Coast States of Oregon, Washington, and California, and in the Rocky Mountain States of Montana, Idaho, and Colorado.

In all, Alaska has about 106 million acres of forest land, about 32 percent of its total land area. An estimated 22.5 million acres of these forests have a growth potential in excess of 20 cubic feet per acre. However, because of geographic and economic remoteness, none of this forest land can be considered commercially exploitable at the present time. For the most part, timber growth in the interior of Alaska is limited by permafrost, poor drainage, and short growing seasons. Because of a history of frequent forest fires, most of the interior forests of Alaska are relatively young and occur in a patchwork of mixed classes and types.

The 482 million acres of land classed as commercial timberland in 1977 was 5 percent less than in 1962. The rise in commercial timberland areas resulting from agricultural land abandonment in the eastern United States from the 1930s to the early 1960s has been reversed. Recent declines in commercial timberland were largely in the South and the Rocky Mountains. Much of the reduction in the West, especially in the Rocky Mountains, reflected shifts of public lands in the national forests to reserved or deferred status in response to growing demands for public recreational use; but some of the reduction was the result of increased use of forest land for roads and urban expansion. In the South, considerable commercial timberland acreage was recently cleared for soybeans and other crop production. This clearing particularly happened in the hardwood areas of the Mississippi River flood plain.

In addition, areas of forested uplands were converted to pasture for the South's growing cattle industry. In all regions, areas of forest land have been taken over for suburban development, highways, reservoirs, and other nontimber use, but because of the large acreage the rate of conversion does not appear to be a significant threat.

Largely as a result of historical policies that encouraged transfer of public domain lands to private ownership, commercial timberland is predominantly private. Ownership in millions of acres by type in 1977 was as follows: national forests, 89; other Federal, 4.9; other public (State and local), 29; forest industry, 69; farm, 116; and other private, 162. The latter two types of ownership account for approximately 58 percent of the total acreage, but a smaller percentage of the wood products.[7] (See *table 2.*) For all forests in 1977, 45 percent of the commercial acreage contained sawtimber stands. The proportion of sawtimber acreage for national forests is well over half; for forest industry forests and for farm and other private forests it is about half.

Some 865 different species of trees have been identified as native to the United States; of these, about 210 have commercial value for their wood. Fourteen species or groups of species are included in major forest types. (See *table 3* for data on commercial timberland by forest types.) Eastern and southern hardwood forest types occupied over half of all commercial timberlands in 1970, and western hardwoods occupied less than 3 percent. Softwood commercial forests, totaling 207 million acres, were almost equally divided, with 105 million acres in western areas and 102 million acres in eastern and southern areas.

While acreage in hardwoods is greater than that of softwoods, the total volume of wood and the volume per acre for commercial forests is about twice as great for the softwoods. Moreover, the average growth rate of softwoods is greater; in 1970 it was 50 cubic feet per acre as compared to about 30 for hardwoods. A softwood tree such as the southern pine may reach sawlog size in 40 years or less, but other softwood trees may take 75, 100, or more years. Used both for sawtimber and pulpwood, the quick growing southern pine that covers the largest area of the eastern and southern softwoods will surely get consideration in future forest production.

STATUS OF TIMBER RESOURCES

Timber Removal

Timber removed from growing inventories on commercial timberland includes: harvests of roundwood products such as saw logs, veneer logs,

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[7] U.S. Department of Agriculture, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington: Government Printing Office, 1982), pp. 119-120.

TABLE 2. AREA OF COMMERCIAL TIMBERLAND IN THE UNITED STATES, BY SECTION AND OWNERSHIP, JANUARY 1, 1977

Ownership	Total United States		North	South	Rocky Mountain	Pacific Coast
	Area	Proportion				
	Million acres	*Percent*	*Million acres*	*Million acres*	*Million acres*	*Million acres*
Federal						
National forest	88.7	18.4	9.8	11.0	36.4	31.5
Bureau of Land Management	5.8	1.2	(1)	(1)	1.7	4.1
Other Federal	4.9	1.0	1.1	3.3	.1	.4
Total Federal	99.4	20.6	11.0	14.3	38.2	36.0
State	23.4	4.9	12.9	2.5	2.2	5.8
County and municipal	6.8	1.4	5.6	.7	.1	.4
Indian	6.1	1.3	1.0	.2	2.7	2.2
Forest industry	68.8	14.2	17.9	36.2	2.1	12.5
Farmer	115.8	24.0	46.0	55.9	8.3	5.6
Other private	162.2	33.6	71.7	78.2	4.2	8.1
All ownerships	482.5	100.0	166.1	188.0	57.8	70.5

[1] Less than 50,000 acres.

NOTE: Data may not add to totals because of rounding.

SOURCE: U.S. Department of Agriculture, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington: Government Printing Office, 1982), p. 121.

and pulpwood; logging residues; and other removal caused by changes in land use, such as clearing for agriculture or housing developments and the withdrawal of forest lands for parks or other nontimber uses. Timber removal in 1976 totaled about 14 billion cubic feet, substantially above levels in the 1950s and early 1960s when removal averaged about 12 billion cubic feet. Softwoods made up some two-thirds of all growing stock removal.

By far the largest portion of timber removal from growing stock consists of roundwood timber products. In 1976, 88 percent of all softwood removal and 68 percent of all hardwood removal were of this type. In addition to harvests of roundwood from growing stock, significant roundwood harvests—about 1.1 billion cubic feet in 1976—were produced from rough and salvageable trees, dead trees, and other nongrowing stock sources. Total harvests of roundwood timber products from all sources thus amounted to an estimated 12.9 billion cubic feet in 1976.[8] (*table 4*) Projections for future roundwood supplies put the total for 1990 at 17 billion cubic feet. Sawtimber supplies in 1970 amounted to 59.3 billion board feet. Projections for future sawtimber supplies put the total for 1990 at 64 billion board feet.[9]

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[8] Ibid., pp. 138-141.

[9] Department of Agriculture, *Outlook for Timber*, pp. 50-51.

TABLE 3. AREA OF COMMERCIAL TIMBERLAND IN THE UNITED STATES, BY FOREST TYPE, 1977

Forest type	Total area	Proportion
	Million acres	*Percent*
Eastern types		
Softwood types		
Loblolly-shortleaf pine	50.0	10.4
Longleaf-slash pine	16.8	3.5
Fir-spruce	17.6	3.6
White-red-jack pine	11.8	2.4
Total	96.1	19.9
Hardwood types		
Oak-hickory	108.9	22.6
Oak-pine	34.6	7.2
Oak-gum-cypress	26.7	5.5
Maple-beech-birch	36.2	7.5
Elm-ash-cottonwood	22.3	4.6
Aspen-birch	19.2	4.0
Total	248.0	51.4
Nonstocked	10.0	2.1
Total East	354.2	73.4
Western types		
Softwood types		
Douglas-fir	30.9	6.4
Ponderosa pine	26.6	5.5
Fir-spruce	19.9	4.1
Lodgepole pine	12.7	2.7
Hemlock-Sitka spruce	12.9	2.7
Larch	2.4	.5
White pine	.4	.1
Redwood	.7	.1
Other western softwoods	.5	.1
Total	107.0	22.2
Western hardwoods	14.9	3.1
Nonstocked	6.4	1.3
Total West	128.3	26.6
United States	482.5	100.0

NOTE: Data may not add to totals because of rounding.

SOURCE: U.S. Department of Agriculture, *An Analysis of the Timber Situation in the United States, 1952-2030,* Forest Resource Report No. 23 (Washington: Government Printing Office, 1982), p. 121.

Timber Inventories and Wood Supply

During the next few decades most timber harvests must come from trees now standing on commercial timberlands. Consequently, the composition, location, quality, and ownership of this standing timber is of major importance in appraising the present and prospective timber situation. Commercial timberlands of the United States supported some

TABLE 4. OUTPUT OF TIMBER PRODUCTS IN THE UNITED STATES, BY SECTION, SOFTWOODS AND HARDWOODS, AND PRODUCT, 1976

(Million cubic feet)

Species group and product	Total	North	South	Rocky Mountain	Pacific Coast
Softwoods					
Saw logs	5,210	267	1,599	641	2,703
Veneer logs	1,330	3	498	65	764
Pulpwood	2,608	335	1,938	25	310
Miscellaneous industrial	238	27	122	18	71
Fuelwood	132	4	77	24	27
Total	9,518	636	4,234	773	3,876
Hardwoods					
Saw logs	1,432	700	667	1	64
Veneer logs	100	34	63	([1])	3
Pulpwood	1,155	454	677	([1])	24
Miscellaneous industrial	139	100	38	2	([1])
Fuelwood	470	214	246	1	9
Total	3,297	1,502	1,692	3	100
All species					
Saw logs	6,642	967	2,266	642	2,768
Veneer logs	1,431	37	561	65	767
Pulpwood	3,763	789	2,615	25	334
Miscellaneous industrial	378	127	160	20	71
Fuelwood	602	218	323	25	36
Total	12,815	2,138	5,925	777	3,976

[1] Less than 0.5 million cubic feet.

SOURCE: U.S. Department of Agriculture, *An Analysis of the Timber Situation in the United States, 1952-2030,* Forest Resource Report No. 23 (Washington: Government Printing Office, 1982), p. 142.

792 billion cubic feet of sound (usable) wood in 1976. About 64 percent of this volume was in sawtimber trees, that is, trees large enough to contain at least one log, suitable for the manufacture of lumber. Another 27 percent was in poletimber trees, or trees that are from 5 inches in diameter at breast height to sawtimber size and that are now or prospectively suitable for industrial roundwood. The remaining 9 percent of all sound wood volumes was in rough and salvageable dead trees. Some of this latter material is suitable for lumber and veneer, but most of it is usable only for pulp and other products where log quality requirements are more flexible.

Softwoods predominate in the Nation's timber inventory; they account for about 61 perent of the total volume of all classes of timber. Approximately one-half of the softwood growing stock inventory and 59 percent of the sawtimber inventory are on the Pacific Coast. This distribution reflects the concentration of timber in western old-growth stands with relatively high volumes per acre. Most of the commercial timberland, however, is in the East. About 26 percent of the U.S. softwood sawtimber inventory in 1977 was Douglas-fir—the country's most important softwood species.[10]

Eastern softwoods, including mainly southern pines, made up 20 percent of the Nation's growing stock in 1977 and about 17 percent of its softwood sawtimber volume. Most southern pine timber is relatively small, with four-fifths of the inventory in trees less than 15 inches in diameter. Nonetheless, the South has been the source of about a quarter of the softwood lumber and plywood and of three-fifths of the softwood pulpwood produced. Inventories of fir, white and red pine, hemlock, cypress, and other eastern softwoods are also concentrated in the smaller sizes.

Hardwoods made up about 36 perent of all classes of standing timber in 1970 and about 25 percent of all sawtimber. More than half of all hardwood growing stock was in the North. Approximately 41 percent was in the South and the remainder in the West. Two-fifths of the hardwood sawtimber volumes in 1977 was in select species—that is, select white and red oaks, hard maple, yellow birch, sweetgum, yellow poplar, ash, black walnut, and black cherry. The remainder of the hardwood sawtimber was composed of upland oaks, hickory, beech, cottonwood, and various other species that have more limited potential for high-quality hardwood products.[11] Only 11 percent of the hardwood growing stock volume in 1970 was in trees 19 inches and larger in diameter at breast height, making the supply of hardwood timber suitable for quality products very limited.

Again using 1977 figures, 46 percent of the softwood timber inventory was in national forests, while only 8 percent of all hardwood growing stock was in national forests. Farm and miscellaneous private ownerships had the major part of the hardwood inventory—about 70 percent—and 27 percent of the softwoods. Forest industries held about 16 percent of all softwood inventories and a somewhat smaller proportion of hardwoods. Thus, wood-using plants in the East must look to nonindustrial private ownerships for much of their timber supply, while many western firms depend on national forests and other public lands for much of their log requirements.

Comparisons of net annual growth and removals of timber indicate an improving relationship between the two. During the past two decades net annual growth in the eastern sections of the United States has been considerably higher than removals, while cut has been exceeding growth in the West. The excess of growth over removals is heartening, but its significance should not be exaggerated. Much of the growth is in small trees that frequently are not of the quality or type most desired, while trees that are cut are mostly large.

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[10] Department of Agriculture, *An Analysis of the Timber Situation*, p. 126.

[11] Ibid., p. 127.

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How Much Land Should Be Devoted to Forests?

The acreage of forest land likely to be diverted from forestry to nonforestry uses is small compared with the total area. The need for forest land is not so acute as to require the preservation in forest of all land capable of growing commercial trees. The difficulties of trying to protect forest land from conversion to nonforest uses are so great that the results are not worthwhile. There are other ways—more intensive production from better sites, in particular—to get needed output of forest services of any type (not merely wood). Society should not expend any significant effort to retain in forestry all land now in forests. However, this does not mean that society should not control the other uses of land that might develop on currently forested land. The high-promotional development of vacation or second homes on forest and other land has grave environmental, economic, and social consequences; moreover, these consequences warrant social controls over this type of land conversion, but not for the purpose of preserving the land in forests.

The current unstocked or understocked tree cover on potential forest land should be restored or improved on the most productive forest sites but not on the least productive commercial forest sites. The Forest Service site productivity classification is used. This classification is based on physical criteria only (cubic feet wood growth per acre annually).

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[12] The conclusions on these policy issues are extracted from Marion Clawson, *Forests For Whom and For What?* (Baltimore: Johns Hopkins University Press for Resources for the Future, Inc., 1975), pp. 158-170. Reprinted with permission of the publisher. Clawson presents facts and ideas on these issues in the final chapter of his book, "One Man's Conclusions on Forest Policy Issues." Clawson, a professional economist with experience in dealing with natural resources, is well qualified to provide expert judgment on forest policy. Not everyone agrees with Clawson's conclusions, but it is believed they provide worthwhile insight into the seven policy issues mentioned above.

Restocking or improving stocking is desirable for land in site classes I through III or generally for better forest sites where trees will grow rapidly and where the wood has significant value. For mediocre forest sites, site class IV generally lets nature take its course. Such sites will reforest naturally, though slowly. The first tree crop may be poor, but ecological succession will work to restore original forest types. If the replanting of sites and the harvesting of the resulting wood can be done inexpensively—circumstances that apply to some site class IV pine lands in the South—replanting may be economic on these below average sites. For the poorest forest areas, site class V, reseeding and replanting is usually simply not worth the cost. Not only should little or no public funds be spent to replant or to improve forest cover on public forests of this site class, but they should not be spent for replanting similar lands in private ownership. If private landowners wish to invest in stand regeneration or improvement on such poor sites, they should be warned that the income prospects are not good.

There are some exceptions that may require stand regeneration on poor sites. If there is a particularly fine stand of some species of trees that is near a city and often used and admired by many people, then it probably should be saved from harvest or land conversion. Replanting may be worthwhile on a tract of land where thin soils would make tree growth slow. The replanting would be costly in terms of wood production, but it may be worthwhile because the land is suitable for recreational purposes. Early restoration of some type of plant cover on bare land may be needed to reduce soil erosion. Some sites, classified low on the productivity scale using physical criteria only, may have economic prospects good enough to warrant replanting, drainage, or fertilization that may economically raise the classification of the site. A particular trace of poor forest land may be planted as part of a planting operation that includes a larger surrounding area of higher site quality.

How Much Commercial Forest Land Should Be Withdrawn from Timber Harvest?

The amount and location of commercial forest land to withdraw from all timber harvest depends upon the purpose of the withdrawal, the productivity site classification of the land, its ownership, whether the land is now covered with merchantable timber, or whether the tree cover must be restored. The purpose of the withdrawal may be to conserve the soil against undue erosion, to preserve some scenic value, to make the area available for recreation, to preserve watershed value, to protect wildlife, or to preserve it for scientific value or as a wilderness area. Harvest may be foregone in some instances because forest regeneration of the site is doubtful. Productivity site classification is the most important factor in considering which lands to withdraw from timber harvest. Income loss from withdrawing low productivity sites is small, but monetary income loss from harvesting high productivity sites is large. When a site currently has a high volume of good quality merchantable timber, which warrants harvesting and the costs of harvest are less than the value of the timber, then withdrawal means some loss of immediate income. Withdrawal from future harvest of a site recently harvested or denuded by fire or storm means a loss of future income. Publicly owned forests may more appropriately be withdrawn to secure nonmonetary values than many privately owned forests. The private landowner will be less inclined to take into account values that cannot be realized but accrue to others.

Publicly owned commercial forests of a low productivity site class that are now generously forested from timber harvest should be withdrawn for all the purposes mentioned above. Such merchantable stands of timber should be coupled with a program to grow wood more intensively on the more productive sites. In making withdrawals for soil conservation, watershed preservation, wildlife protection, and other similar conservation purposes, the line between withdrawal and harvest is not always easy to draw. It is affected by technology and care in timber harvest. The method of timber harvest (selective, shelterwood, clearcut, or other) will have some effect on the decision to withdraw for some reasons but not for others. Roads can be built to lie lightly on the land; logs can be removed by "walk-lightly" methods; under some conditions trees can be left to protect water from adverse effects; and other measures can reduce environmental impacts. Moreover, withdrawal of these less productive sites should be tempered by some consideration of their extent in relation to productive forest sites. For instance, in the Pacific Northwest more forest land lies in high productivity classes; hence, most of the less productive sites could be withdrawn. Whereas, in the Black Hills of South Dakota little forest land would be left for harvest if all the lower productive sites were withdrawn from harvest.

On publicly owned commercial forests of low-site productivity, where the once existent timberstand has been harvested, little money should be spent to restore the stand, and the site should not be expected to be harvested for another 100 to 200 years, if ever. This position could usually rest solidly on the economics of timber growing on such sites. These sites might be used for other forest outputs or uses.

On publicly owned commercial forests on more productive sites, land should be withdrawn from timber harvest sparingly. Most such lands would pose only mild conservation problems because of timber harvest; therefore, withdrawals for this purpose do not need to be extensive.

Since the economic values from timber growing and timber harvest are higher on the most productive sites, economic criteria for using such forests should be applied more strictly than for less productive forests where the economic values are low.

Withdrawal of forest land for wilderness purposes does not differ conceptually from withdrawals from timber harvest for any other purpose. In each case, there should be a clear definition of the purposes of the withdrawal, a measurement of the gains from withdrawal and from harvest, and a delimitation of the appropriate area. Public forest lands of low site productivity should be withdrawn generously, and higher productivity lands should be withdrawn sparingly. Wilderness use should not be excluded from all productive forest sites, but the cost of withdrawals on these sites should be counted. Economic analysis should not be applied too strictly to the establishment of wilderness areas. A few areas with some wilderness appeal should be favored even if it could be proven that their economic value would be higher for timber growth and harvest. There should be concern for cost, value, and alternative use of the forest. Generous withdrawal of forest for wilderness use should be contingent upon the wilderness lovers and the public forest management agencies agreeing to some means of limiting wilderness use to capacity. If excessive use is to destroy its capacity to provide a wilderness experience, why bother to establish a wilderness?

For privately owned forests, the withdrawal situation is somewhat different. The private forest owner, whether large or small, will follow personal long-run interests except as restrained by law or by public opinion. Law or public opinion may well enforce conservation measures on private forests if the consequences of timber harvest have adverse off-site effects. Such constraints may be on output standards, letting the forestowner meet such standards as well as possible. Private landowners will harvest existing stands of timber if it is profitable, even on the less productive sites. Since many of these sites have stands of timber that are not highly profitable to harvest and since the economics of timber growing on such sites are unattractive, such sites might be acquired by a public agency and used for nonharvest forest uses. On the more productive forest sites, where intensive forestry is economic, private forestowners are expected to make few withdrawals from timber harvest.

These various considerations can be translated into specific proposals for withdrawal of forest from harvest in many different ways. Innumerable possibilities exist to produce more wood than is being grown today and simultaneously withdraw substantial acreages of forest from harvest. A willingness of the various contenders for forest land to search diligently and constructively for mutually acceptable forest management programs should pay off handsomely with constructive results.

How To Harvest Timber

Numerous groups have tried to outlaw or forbid clearcutting in public forests. However, the issues are broader than merely clearcutting. Significant areas of commercial forest land should be reserved from cutting by any method. How large the reserved acreage would be is not known because there is an unknown but substantial overlap of areas withdrawn from harvest for conservation, recreation, wilderness, wildlife, watershed, and aesthetic reasons. If the reservations from harvest were very generous, they could possibly be as much as a fourth of all commercial forest land including commercial forest in site class V. Whatever the percentage of commercial forest areas reserved, the proportion of forest productive capacity reserved from cutting would be less than half as great. This is inherent in the classification of forest land by site class.

What is the purpose of any timber harvest by any method? If the purpose is merely to get out the merchantable timber in the least expensive way, then sometimes the least expensive method is clearcutting, but more often the cheapest way is a poor type of selective cutting. The logger frequently takes all the trees that he thinks he can run through his saw, and he takes few pains to preserve the other stems. When there is a mixture of species, he takes the more valuable ones, leaving the less valuable ones to capture the site. The result may be a tree cover remaining on the ground, but the true forest has been destroyed. Clearcutting under these circumstances would have been more costly, but the forest naturally established after such a harvest, would have been an ecologically and economically more productive one. This process of selective cutting, or something close to it, has created some millions of acres of mediocre to worse hardwood stands throughout the eastern half of the United States. Clearcutting for economic reasons may also leave an area poorly equipped for reproduction as well as aesthetically offensive during the regeneration period. The degree of skill with which any method is employed may be high or low.

If timber harvest is viewed as an indispensable tool in forest management and in tree growth, then the method of timber harvest should be selected with management objectives in mind. For most forests, renewed tree cover, continued tree growth, and preservation of the basic productive capacity of the forest's ecosystem will be among the management objectives. If these are the objectives, then the characteristics of the site become all important. The method of timber harvest may be selective cut, shelterwood cut, clearcut, or some other form equally appropriate under different conditions. Where there is a forest of mixed ages, as ponderosa pine generally is, or of both mixed ages and mixed species, as many eastern hardwood types are, then a cut selecting among trees on the basis of size, age, thrift, and perhaps species is often the indispensable forest management tool. For some of the warmer and drier sites for Douglas-fir, especially on the eastern and southern edges of the Douglas-fir belt, shelterwood cutting may be the best method of timber harvest. Shelterwood cutting is a method whereby one cut takes some mature trees, but others are left for some years for seed and ground shelter and removed later. For some sites and species, clearcutting to expose mineral soils for new seedlings to root and provide sunlight is indispensable. For a badly degraded mixed hardwood site, the only way desirable species and trees can be reestablished within less than a few generations may be to remove all existing trees (clearcut) and start over. A lodgepole pine site of even-aged but overmature trees heavily infested with dwarf mistletoe must be clearcut if a clean new stand is to be reestablished. For this latter situation, no cutting at all may be the most economic forest management if the site is very low in productivity or if natural regeneration is uncertain and slow. In short, the competent forester who seeks to manage the forest for continued high-level wood production must use the most appropriate method of timber harvest as an indispensable management tool.

The method of timber harvest has special characteristics in mature old growth forests. Most such forests are part of the national forests and are mostly some type of pine or Douglas-fir. Some of the trees in such stands have died and some have fallen. There is much defective wood in the standing live trees as well as on the ground. Any method of harvest that removes only the wood that can be economically removed will leave large volumes of defective wood behind. Such defective materials can be and should be removed for aesthetic and other reasons by piling and burning.

Timber harvest by any means may be aesthetically offensive, but the bad effects can be lessened with proper care. Clearcutting is always a shock, ecologically and aesthetically. But the extent of the shock can be reduced by more care in laying out the harvest area, by disposal of slash and waste, and by prompt regeneration.

When considering the method of timber harvest, it is essential that the full physical-biological and economic potential of intensive forestry be kept in mind. If most of the Nation's wood were grown on the better forest sites under economically sound intensive forestry methods, tree harvest would come from a much smaller total land area than if all so-called commercial forests were cut, but a given tract of forest would be cut much more frequently than it would be cut today. After the initial harvest, there would be far less defective material in subsequent harvests. Each harvested tract would get back into tree growing more promptly than it does today. More of the total forested area would not be cut at all or would be cut only very infrequently. The whole regimen of tree growth, tree harvest, and stand regeneration would be different for the intensively managed and the less intensively managed sites.

National Forest Management

The national forests include a very large area of land with many diverse natural resources and demands on those resources. Approximately half their total area is commercial forest including site class V land. The focus in this section is on the problems of managing the mature old growth timber stands and their ultimate conversion to a rotation of growth and cut.

The national forests, including site class V land, contain slightly more than half of all the standing softwood sawtimber in the United States. Their inventory of both standing sawtimber and standing total timber per acre is the highest of any major type of forest land ownership. The national forests' rate of annual wood growth – whether expressed as cubic feet per acre, as a percentage of the volume of standing timber, or as a percentage of the potential capacity – is the lowest of any major type of forest land ownership. They are an immense storehouse of mature, somewhat defective, nearly nongrowing timber, and there is a great annual loss of dead and decaying timber. The immense inventory value of the standing timber in national forests at its very slow growth rate is shocking. This is hardly physically or economically productive. In their own way, these forests are as unproductive as bare potential forest sites.

Even with generous reservation of national forests for wilderness and other nonharvest uses, the harvest of old growth timber on national forests should be substantially accelerated above current rates. In a mature forest, harvest inevitably exceeds net growth, whether or not it exceeds long-term sustained yield. An accelerated harvest on national forests for the next two decades would almost certainly be well above net wood growth. However, growth would rise considerably as old growth areas were harvested, assuming that intensive forestry was followed on the better sites. The inventory of standing timber on national forests should be reduced; it is excessive from a silvicultural point of view (care of forests), and it is grossly excessive from an economic viewpoint. If the national forests are ever to grow more timber, at a rate closely approaching their potential, then more timber must first be cut from them. It would be possible to accelerate their timber harvest greatly while remaining within the principle of sustained yield.

An acceleration in cutting old growth timber in national forests would undoubtedly pose difficult technical and economic problems. But the most serious problems would be cultural acceptability. The 100-year-and-longer conversion of mature old growth specified in the Forest Service Manual would have to be changed. To many people, foresters and nonforesters inside and outside the Forest Services, a marked acceleration of cut of old growth timber would be a traumatic experience. Nevertheless, if the national forests are to produce as much as they are reasonably capable of producing, their management must be changed in the future. Nonforesters have a right to ask foresters to work out and implement a program of national forest management that is economically productive and attuned to the needs of the times. One aspect of such management must be more intensive management of the lands used for timber production. This requires greater expenditures and, therefore, larger appropriations and better assurance of continued adequate support.

Output from Small Private Forests

The "other" private forests (those not owned by the forest industry) include approximately 60 percent of the entire forested area of the United States. While a few owners have some thousands of acres of land, most such ownerships have only a few hundred acres or less. Many of these ownerships include land of lower site quality; however, on the whole they average almost as high in productivity as all other forests taken together but considerably lower than forest industry forests. In 1970, the other private forests were more lightly stocked with growing trees than was any other major type of forest ownership; their net growth rate per acre, however, was above average and was almost double the admittedly low net growth rate on national forests. Harvest in 1970 was substantially below growth, so inventory of standing timber was being built up.

An on-the-ground inspection of many of these forests will show that the present timber stand has been badly degraded by past harvests of the type previously described. In addition to having a light volume, these stands often include poorer species or poorer individual trees. Observations of the management of such small forests will often show that the periodic harvests are poorly planned and conducted in terms of what is done to the remaining timber stand and economic returns to the owner. It is often said that the owners of these small forests lack knowledge about how to manage them better and need technical advice and assistance.

Is the accomplishment of the owners really so bad given the circumstances under which they must operate? They may attain a comparatively low output from their forests, but they also expend little on them. They have not overinvested in timber stand. They may be poor foresters, but possibly they are as good in forest economics as their advisers.

As long as the rain falls and the sun shines, these small private forests (whatever their site class) will produce some wood, which can be harvested at intervals. The issues revolve around attempts to increase their output over that which would occur "naturally." Public and private programs other than fire protection have been rather unrewarding in the past. Current public and private programs aimed at increasing the output of the small private forests should be continued. The new approach to the problem described should be tried, under which a system of leasing land from small owners to form larger management units would be subsidized by Federal grants. There must be other approaches that would also be rewarding.

If it is culturally and politically acceptable to do so, public and private programs for these forests should be limited to those on the average or better forest sites, to those of the average or larger acreages per ownership unit, and to those with wood production for which there is an active demand. Greater returns per unit of expenditure will be achieved in this way. A program limited to the larger and better situated private forestowners might seem elitist or discriminatory to some people, even when greater wood output per unit of cost was admitted.

Environmental Policy Issues Involving Forests

The environmental policy issues involving forests fall into two categories: those involving forests as one of several other sources of raw materials and those within forestry itself. Wood is a versatile and valuable raw material used throughout the world. It is renewable; it grows; and it is biodegradable when it is no longer needed for its original purpose. The fuel requirements of wood manufacture are generally less than those for alternative raw materials. In a world that is becoming increasingly environment and energy conscious, wood has many advantages.

A greater use of wood should not be accepted as an excuse for not instituting greater environmental protection and conservation for fuels and metals. Nor should a greater use of wood be a justification for every use of wood, fuel, and metals. Some forms of consumption of metals and energy may be socially undesirable and should be or will have to be curtailed in the future. But, for many forms of consumption that will continue, wood fibers in some product form or another are technically and economically good substitutes for metals and indirectly for fuels. Environmental concerns will lead to greater relative use of wood in the future.

In forestry, more attention must be given to environmental impacts. The method of timber harvest is particularly important, but environmental protection measures are not limited to timber harvest methodology. Road locations, construction standards, and mileages are very important, regardless of whether the roads are used for timber harvest or recreation. Ninety percent or more of the accelerated erosion associated with timber harvest has come from roads rather than other logging operations. Greater attention will also have to be directed to preservation of water quality in streams and lakes, preservation and care of wildlife, and forests aesthetics. The environment must be considered in all uses of forests in the future.

How is this desired result to be attained? Stricter environmental considerations have too often been neglected in the past. The requirement for environmental impact statements and the possibility of citizen suits to enforce this process may bring needed changes. Education of forestowners, managers, and timber harvesters is essential but is likely to be insufficient. There are many complexities and ramifications of laws that closely control forest operations on private land, but how else does one deal with the forestowner or timber harvester who resists any other approach?

Exports of Forest Products

Imports of lumber from western Canada, imports of hardwood and plywood from Japan and elsewhere in the Pacific, imports of newsprint from eastern Canada, exports of paper and paperboard to Europe from the southeastern United States, and exports of woodchips from the Pacific Northwest to Japan have not raised any serious policy issues. The only significant policy issues with respect to foreign trade in forest products relate to log exports to Japan.

Continued export of logs to Japan does not reduce our domestic supply of wood. If the Japanese were cut off from U.S. log exports, they would buy lumber in the United States or Canada; they would buy unwillingly, but most probably in about the same volume as they now buy logs. Therefore, the U.S. supply of lumber would not be increased significantly, if at all, by a cessation of log exports. While log export increases competition for logs in the Pacific Northwest, there is no good reason for sheltering such firms from competition. Log export may slightly increase wood prices in the United States, but this is not a serious problem. Log export should be increased over a period of years. With the increased harvest of old growth timber on national forests and with increased wood growth on forests of all ownerships, increasing log export would be possible without seriously disrupting current domestic supply. More importantly, if the United States is going to continue to import some of the metals and other raw materials it needs and import the manufactured products it wants and can get cheaper by importing, then we must export something. We have priced ourselves out of the international export markets for many industrial products, but our natural resources and our productive manpower and management enable us to compete very well in world markets for farm commodities and forest products. When we export logs and import metals, we trade an environmental impact in our forests, which by careful management can be very small, for an environmental impact in mining and refining, which may be great.

Support for long-run substantial log export is not incompatible with suggesting that there may be times when the Japanese might appropriately be urged by our Government "to cool it." The demand for lumber in this country for building construction fluctuates so that sharp rises in lumber prices followed by almost equally sharp declines take place at intervals. If the Japanese were to increase their log buying to expand their housing construction at the same time as our domestic demand was sharply rising, then a difficult supply-demand situation would be exacerbated, and appeals for legislation to control log exports would increase. The Japanese, given the nature of their economy and the role of government in that economy, could surely find a way to step up their log buying when U.S. demand for lumber is weak and to decrease it when U.S. demand is high. Over a period of years they could buy a large amount of timber in the United States with minimum disturbance to U.S. markets.

MANAGEMENT AND CONTROLS

The controversy over forestry management policies sharpened as timber consumption took a dramatic upswing beginning in the mid-1960s. The debates between conservation groups and those who proposed to increase timber harvest centered on the supplies from national forests and other publicly owned land; these supplies accounted for about 27 percent of all forest land and yielded 24 percent of the timber. With pressures increasing in 1969 for expanding wood products supplies, lumber interests (headed by the National Forest Products Association and the National Association of Home Builders) stepped up lobbying efforts to revise allowable annual national forest harvesting rates subject to the Multiple Use-Sustained Yield Act of 1960. In its turn, the Conservation Coalition, an alliance of 10 conservation groups, undertook an intensive campaign to fight increased harvesting, maintaining that the Forest Service was already selling timber at a rate 50 percent in excess of levels acceptable to maintain the health of the forests. The Forest Service made successive increases after 1950 in the allowable cut, which is the amount of timber that may be harvested from national forests under lease without depleting the forests. The allowable cut was increased from 6 million board feet in 1950 to 11 billion board feet in 1960 and to 13.5 billion board feet in 1970.[13] The Forest Service attributed these increases to changes in classification, increased reforestation, and technological improvements. The Congress was unable to come to agreement on the issue of timber from national forest lands in the early 1970s. Although a short-term measure, when lumber prices skyrocketed because of growing domestic lumber shortages in 1973, Congress acted to limit timber exports.

The report of the President's Advisory Panel on Timber and Environment, which was endorsed by the President in September 1973, recommended increases in timber cutting of 50 to 100 percent in national forests in the West. The report also recommended a number of other measures to increase timber production. Environmentalists attacked the report, charging that timber production was overemphasized to the detriment of plant and animal life. The administration, in response to pressures from builders and wood consumers, supported increased timber production from Federal lands and directed that recreational use of the Nation's forests be deemphasized in order to increase timber harvesting in fiscal year 1974. After more debate on forest policy in the Congress, a forest management bill was passed and became law (Public Law 94-588) in October 1976. Among the several provisions of the act was permission for clearcutting in national forests but under certain conditions. From the timber industry's viewpoint, the act was considered a good compromise because in the *Monongahela* decision in 1973 the courts had ruled for the banning of clearcutting in Monongahela National Forests, a decision that was upheld when appealed. The Organic Act of 1897—on which the environmentalists based their court case against clearcutting—limited sales of timber from national forests to trees that were dead, mature, and of large growth. Such trees could be individually marked for harvesting and, once harvested, had to be hauled away. Before passage of the 1976 act the language of the Organic Act of 1897 had been interpreted as prohibiting the sale of timber in certain national forests. The older act was repealed and clearcutting was permitted if it would be the optimum method under the land management plan and an interdisciplinary review had been made. Timber harvesting is permitted only when irreversible damage to soil, slopes, and watershed would not occur; lands could be restocked within 5 years; water bodies would remain protected; and the harvesting system used was not chosen primarily for economic reasons.[14]

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[13] Congressional Quarterly Service, *Congress and the Nation III*, p. 118.

The 1976 forest management act also required the Forest Service to manage the national forests under the principle of evenflow sustained yield, a practice that had been laid down and followed by the Forest Service since the passage of the Multiple Use-Sustained Yield Act of 1960. The latter law stressed that national forests should provide a broad range of uses – timber, recreation, soil, water, wildlife, grazing, and aesthetics.

Other provisions in the 1976 act established standards and guidelines for management of national forests; authorized $200 million annually for reforestation efforts beginning in 1978; called for public participation in the development, review, and revision of land management; gave Congress oversight responsibility for acquisition of national forest lands while abolishing the National Forest Reservation Commission; and assigned requirements to the Secretary of Agriculture relating to forestry development.

In 1971, The Forest Service undertook the Roadless Area Review and Evaluation (RARE I). In 1977, the Carter Administration began RARE II because proponents of wilderness were not satisfied with the results of the first review. At one time as much as 62 million acres of the total 192 million acres of the national forests were temporarily withdrawn from multiple-use management pending their review and appraisal as agreed in a court suit brought by conservation groups. In addition, very large areas of the Bureau of Land Management (BLM) lands, including lands in Alaska, were under review for possible inclusion in wilderness. The RARE II report recommended that 15 million acres be included in wilderness within national forests, 36 million acres be released from further consideration, and 10 million acres be reserved for further study. Of the areas under BLM management, 23 million acres were recommended for further study and the rest were recommended for release from further consideration.[15]

Since 1979, Congress has been working its way, State by State, through the recommendations of the Carter-era RARE II study identifying undeveloped national forest lands for permanent protection as national wilderness. Although the House passed a number of wilderness bills in 1983, most remained frozen in the Senate until 1984. One wilderness bill for Montana was enacted into law in 1983. The Reagan Administration announced in February 1983 that it was scrapping the Carter RARE II recommendations and coming up with its own beginning in 1985. Environmentalists and their congressional allies have been trying to enact as many bills as they can before the Reagan recommendations come out.[16]

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[14] Congressional Quarterly Service, *Congressional Quarterly Almanac*, 1976 (Washington: Congressional Quarterly Services, 1976), pp. 192-197.

[15] Marion Clawson, *The Federal Lands Revisited* (Washington: Resources for the Future, Inc., 1983), p. 46.

Eleven wilderness bills were enacted into law in 1984. President Reagan signed bills designating millions of acres of land as wilderness area, making California second only to Alaska in the amount of wilderness. California now has 5.9 million acres of wilderness. The new California addition expands the existing 2.7 million acres in the National Wilderness Preservation System with 1.8 million acres of roadless Forest Service land and 1.4 million acres in two national parks – 678,000 acres in Yosemite National Park and 737,000 acres in Sequoia National Park.

In Florida, the new law prohibits phosphate mining in Osceola National Forest and protects 49,150 acres of national forest from development. The bill also designates six new wilderness areas in three Florida national forests and adds land to an existing wilderness. The wilderness areas are located in the Appalachicola, Osceola, and Ocala national forests. In Utah, 749,550 acres are added to Utah's wilderness system in 12 national forests. Enactment of the bills ended a struggle that lasted almost a decade among environmentalists; offroad vehicle enthusiasts; and the lumber, mining, and skiing industries.[17]

Five wilderness bills pending before Congress in 1984 designated more than 1.1 million acres in Oregon, Wisconsin, Vermont, North Carolina, and New Hampshire as federally protected wilderness. Other state wilderness bills pending included Arizona, Texas, Missouri, Idaho, Wyoming, and Virginia.

A key issue dividing environmentalists and development interests is what happens to lands not named as wilderness in each State's bill. While those lands are under consideration, the law requires the Agriculture Department's U.S. Forest Service to manage them so as not to ruin their suitability for wilderness status by, for example, building roads into them. Once the lands have been released from wilderness consideration, they are available for any of the other multiple uses made of national forest land: logging, grazing and mining, recreation, and wildlife habitat.

The issue is whether the terms of that land release will be "hard" or "soft." Soft release allows the Forest Service to reconsider an area for possible wilderness status relatively soon (as early as 10 years from enactment) and prohibits the Forest Service from restricting other uses of an area solely to protect its wilderness suitability. Hard release prohibits reconsideration until a later date (15 to 25 years from enactment) and prohibits the Forest Service from restricting other uses of an area solely to protect its wilderness suitability.[18]

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[16] Joseph A. Davis, "State Wilderness Measures Beginning to Move Again After Long Winter Freeze," *Congressional Quarterly Weekly Report* 42 (March 1984): 727.

[17] "Reagan Signs Measures Adding Wilderness Areas," *The Washington Post*, 30 September 1984, sec. A, p. 8.

Environmentalist proposals to substantially expand the amount of Federal land in wilderness areas have intensified the battle between lumbermen and conservationists. Much of the land in dispute is located in national forests where timber companies are permitted to bid for rights to big trees. Lumber industry and business groups contend the lumber from the areas proposed for conservation is needed to meet demands. About one-third of the Nation's lumber needs are met from public land as compared to 60 percent from privately owned forests. Environmentalists assert that their proposed expansion of wilderness areas can be accomplished without creating a lumber shortage.[19]

In many of the areas proposed for wilderness status residents have taken sides with either the lumber interests or the environmentalists and have engaged in heated controversy. One such community is Ely, Minnesota, which is on the edge of the Boundary Waters Canoe Area, part of the Superior National Forest. In 1964 Congress designated the Boundary Waters as a Federal wilderness, but by special waiver allowed continuation of logging, mining, and the use of motorized vehicles in the area. In 1977, Congress considered two bills that would change the status of the Boundary Waters Area: one to ban logging, snowmobiles, and other vehicles in the whole area of 1 million acres, and the other to ban such uses in only 600,000 acres. Emotions ran deep and on several occasions violence threatened the community.

Skirmishes between environmentalists and industry over forest resources are being waged not only in Congress, but by lawsuits brought under various statutes. It appears likely that the debate over use of vital forest resources will continue between the conflicting interests.

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[18] Davis, "State Wilderness," pp. 727-728.

[19] *U.S. News and World Report*, 22 August 1977, pp. 62-63.

VI

NONFUEL MINERALS AND METALS

The mineral products of the earth are so commonly used that they affect every aspect of life. Mineral substances and the materials derived from them, whether in the form of fuels, construction materials, metals for manufacture, tools, chemicals, or fertilizers are the foundation of technical civilization. A mineral is usually defined as a solid homogenous crystalline chemical element or compound that results from the inorganic process of nature. Progress in industry has been accompanied by the consumption of great quantities of the familiar minerals as well as by the use of a growing number of lesser known substances; these substances are usually required in small amounts and often for highly technical purposes. New metals and minerals that have come into use since 1900 include germanium, thorium, vanadium, beryllium, tungsten, selenium, molybdenum, and titanium. These substances are examples of elements that were unknown a century ago or were regarded only as mineralogical curiosities. Today, many of them are essential materials of industry.[1]

Many minerals are irregularly distributed in the crust of the earth, and a particular mineral may be concentrated in relatively few specific locations. The term "resource" is used to indicate a concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible. Total resources include identified or known materials plus those not yet discovered, but which, on the basis of geologic evidence, are presumed to exist. "Reserve" refers to that portion of the identified resource from which a usable mineral or energy commodity can be economically extracted or produced at the time of determination. The term "ore" is used for reserves of some materials.

The requirements of the United States for the world's raw nonfuel mineral production are by far the largest of any nation. With about 5 percent of the world's population and 7 percent of the land area, we consume almost 13 percent of this world's raw nonfuel mineral production. In 1981, when total domestic use of minerals was about 2 billion tons, average per capita consumption was more than 18,000 pounds of nonfuel minerals. The value of U.S. mineral production in 1980 was twice what it was in 1950; however, the U.S. share of world production and consumption was only about half of what it was in 1950. The United States is about 25 percent dependent on raw materials from foreign suppliers and is more than 50 percent reliant on imports for 23 critical minerals. The prominent role of nonfuel minerals in the U.S. economy is evident from the data at figure 3.

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[1] The information in this chapter is taken largely from U.S. Bureau of Mines Publications, in particular, *Mineral Commodities Summaries 1985* (Washington: Government Printing Office, 1985).

The U.S. minerals industry today is part of a worldwide minerals complex, and the increasing mineral demand and competition in world markets compels us to assess our mineral situation in the context of social, economic, and political tradeoffs. U.S. difficulties in acquiring mineral imports have been more a result of constraints in the realm of international relations than of natural supply shortages. Historical patterns of mineral accessibility have been altered by international producer agreements, sanctions, political strife, and nationalization. The United States also encountered increasing competition in obtaining needed raw materials in the world market. As the industrialized nations use up their own high quality sources of low-cost materials, they are turning increasingly to the developing countries for raw materials. The developing countries, in turn, are seeking to increase their role in processing the raw materials they mine in order to obtain a larger share of the returns.

Minerals are nonrenewable resources, stocks are finite, and some readily accessible minerals are not economically available because technology has not been developed to utilize them; nevertheless, there is considerable basis for optimism about future metal supplies. Exploration for minerals has only dented the earth's crust. The deepest mines have penetrated somewhat beyond a mile and the deepest wells to 7 miles. So far, equipment to extract resources from under the sea has been developed to operate only in a few hundred feet of water, and the technology and legal apparatus for exploiting seabed mineral deposits is just beginning to develop. Many areas of the world are yet to be intensively explored by modern geological methods. These include regions with inhospitable terrain, forbidding climate, or undeveloped infrastructures that discourage exploration. New mineral deposits are being located and developed on every continent. The oceans, known to contain minerals in nodule form as well as deposits below the ocean floor, are a promising source of minerals. Geologists are improving their ability to look beneath the surface of the earth using all sorts of improved sensors and computer applications.

The best available data and analysis indicate there are ample minerals available in the earth's crust to meet the world's needs for well beyond the end of the century. Nonetheless, minerals are distributed unevenly about the globe and rising demand periodically has exceeded available supplies, resulting in both shortages and abrupt price rises. In the United States domestic mineral production, especially production of processed minerals, has not kept pace with growth in demand; consequently, there is a growing trend toward importing processed minerals. Among the several factors that tend to impede increased production, research and development efforts, and efficiency of operations are the following:[2]

–Susceptibility to short-term business cycles that increase risk uncertainties for required sustained return on large, up-front capital expenditures;

–High interest rates and producer debt loads that adversely affect profits and attractiveness in capital markets;

–The impact of Federal policies on the economics of new mine development and on modernizing minerals processing facilities, and uncertainties regarding these policies;

–Diversion of financial resources to meet government regulations;

–Government policies that inhibit capital accumulation during periods of market upswings to compensate for periods of market downswings; and

–Difficulties and high cost to achieve major technological innovations.

The domestic minerals industry (mining, smelting, and refining) has encountered severe competition from foreign producers. Some of the difficulties with which U.S. producers must cope are: lower ore grades for some important minerals (for example, iron and copper); generally older and less efficient processing facilities; withdrawals of Federal land, high cost of land-use regulations, and uncertainties of delays; high-cost environmental, health, and safety regulations; comparatively high labor costs; and foreign government incentives to foreign producers. On the other hand, U.S. mineral producers have advantages over many foreign competitors, including the following: well-developed transportation and distribution systems; an efficient and relatively stable labor force; a huge domestic market; a stable political climate; and a wealth of unexplored and highly mineralized land.

In the early 1980s, U.S. import dependence on raw minerals was about 25 percent of consumption, and the country was more than 50 percent reliant on imports for 25 critical minerals. Among the major users of minerals, only the Soviet Union is largely self-sufficient. Europe and Japan are 75 percent and 90 percent dependent on imports, respectively, and there is mounting evidence that the Soviets are finding it more difficult to meet their own and other Eastern bloc requirements.

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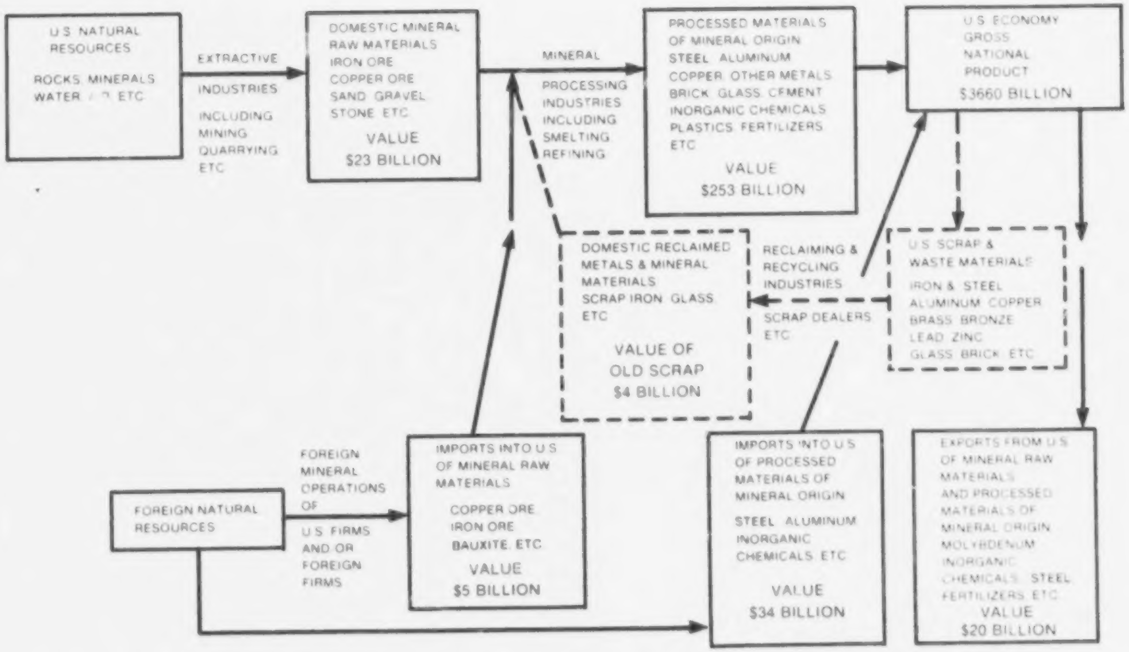
[2] U.S. Bureau of Mines, *The Domestic Supply of Critical Minerals* (Washington: Government Printing Office, 1983), pp. 1-48.


U S NATURAL RESOURCES
ROCKS MINERALS WATER AIR ETC
EXTRACTIVE INDUSTRIES INCLUDING MINING QUARRYING ETC
DOMESTIC MINERAL RAW MATERIALS IRON ORE COPPER ORE SAND GRAVEL STONE ETC
VALUE $23 BILLION
MINERAL PROCESSING INDUSTRIES INCLUDING SMELTING REFINING
PROCESSED MATERIALS OF MINERAL ORIGIN STEEL ALUMINUM COPPER OTHER METALS BRICK GLASS CEMENT INORGANIC CHEMICALS PLASTICS FERTILIZERS ETC
VALUE $253 BILLION
U S ECONOMY GROSS NATIONAL PRODUCT
$3660 BILLION
DOMESTIC RECLAIMED METALS & MINERAL MATERIALS SCRAP IRON GLASS ETC
VALUE OF OLD SCRAP $4 BILLION
RECLAIMING & RECYCLING INDUSTRIES
SCRAP DEALERS ETC
U S SCRAP & WASTE MATERIALS
IRON & STEEL ALUMINUM COPPER BRASS BRONZE LEAD ZINC GLASS BRICK ETC
FOREIGN NATURAL RESOURCES
FOREIGN MINERAL OPERATIONS OF
U S FIRMS AND OR FOREIGN FIRMS
IMPORTS INTO U S OF MINERAL RAW MATERIALS
COPPER ORE IRON ORE BAUXITE ETC
VALUE $5 BILLION
IMPORTS INTO U S OF PROCESSED MATERIALS OF MINERAL ORIGIN
STEEL ALUMINUM INORGANIC CHEMICALS ETC
VALUE $34 BILLION
EXPORTS FROM U S OF MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN MOLYBDENUM INORGANIC CHEMICALS STEEL FERTILIZERS ETC
VALUE $20 BILLION

NOTE: Table gives estimated values for 1984. (December 15, 1984 – based on statistics for first 10 months of 1984 only)

SOURCE: U.S. Bureau of Mines, *Mineral Commodities Summaries 1985* (Washington: Government Printing Office, 1985, opposite p. 1.

FIGURE 3. THE ROLE OF NONFUEL MINERALS IN THE U.S. ECONOMY

The consumption of minerals is strongly related to growth in the economy. U.S. mineral consumption is generally forecast to increase at an annual rate of 1.5 to 3 percent. The goods-producing section of the economy, which uses minerals more intensely than the services sector, has declined from about 58 percent of GNP in 1960 to about 54 percent in 1980. The trend toward high growth rates for services is expected to continue through the 1980s.[3]

Selected nonfuel minerals of importance to the economy and defense industries are discussed in some detail in this chapter. Supply, demand, and dependence on imports and other data are provided on ferrous metals, major ferroalloys, and major nonferrous metals. Included in these major groupings are the minerals designated under the Defense Priorities and Allocations System (DPAS) as "controlled materials" because they are key to effective industrial mobilization—namely in production of steel, copper, aluminum, and nickel alloys.[4] The next chapter explains the U.S. position with respect to nonfuel strategic and critical nonfuel minerals.

FERROUS METALS AND MAJOR FERROALLOYS

Iron and Steel

Iron and steel have been key to the industrialization process and to the modernization of societies. They are consumed in industrialized nations in approximate proportion to the scale of production. Iron is the least expensive and most widely used metal, but in recent years it is increasingly being replaced by other materials such as plastics in many applications. Iron and steel are still relied on heavily for structures, coverings, and mechanical elements. On a tonnage basis steel is the fourth largest U.S. industry, and it accounts for 90 percent of all metals consumed in the United States. The average annual per capita requirement for iron and steel in 1983 was approximately 1,200 pounds. In 1985 estimated domestic production of iron ore was 49 million tons, and the estimated consumption was 65 million tons. From 1980 through 1984 import dependence ranged from 19 percent to 37 percent for iron ore.

U.S. production of steel as a share of the world total has significantly decreased, declining from 47 percent in 1950 to 12 percent in 1984. The net import balance for iron and steel for the period 1980 through 1984 ranged from 13 percent to 23 percent. The U.S. steel industry has experienced a deteriorating world market position over the past two decades as world steel demand has doubled but domestic steel production has increased by only 20 percent. In 1984 domestic steel production was about 45 percent of capacity. The U.S. iron and steel industry has performed poorly in profitability and productivity growth since the mid-1960s. The industry's lack of competitiveness and the inroads into American markets of foreign suppliers have demanded the attention of Presidents since the mid-1970s.

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[3] See the annual publication, *Mineral Commodity Summaries 19--* by the U.S. Bureau of Mines for further information on the individual nonfuel minerals discussed in this chapter. Summary data and information are provided on more than 85 substances in the 1985 issue which was used in preparing this chapter.

[4] U.S. Department of Commerce, *The Defense Priorities and Allocation System* (Washington: Office of Industrial Resource Administration, U.S. Department of Commerce, October 1984). The DPAS is discussed in greater detail in chapter X. It supersedes the Defense Materials System (DMS) and the Defense Priorities System (DPS).

The United States has reasonably good iron ore reserves, but in 1983 the iron ore industry was operating at less than half of production capacity. The U.S. reserve base is estimated at 25 billion long tons (one long ton equals 2,240 pounds) of crude iron ore with an iron content of 5.8 billion long tons (lt). This represents about 12 percent of the world crude iron ore base and about 6 percent of the world total iron content. Long tons for other noncommunist nations holding large crude iron ore deposits are: Australia, 33 billion; Canada, 25.1 billion; and Brazil, 15.6 billion. The combined holdings of the last three countries and the United States represent about 48 percent of the world total, as compared to almost 29 percent for the Soviet Union and other centrally planned economies except China.

Estimated iron ore production in 1984 was 51 million long tons. Imports for consumption amounted to 18 million long tons, and .5 million long tons were exported. Minnesota produced about 71 percent of the total and Michigan about 25 percent; the rest was produced in five other States. About 98 percent of all iron ore was pelletized before shipment. From 1980 through 1983 Canada provided two-thirds of all iron ore imports. In the early 1980s world iron production and trade were at a low level because of the depressed demand for iron and steel in most major countries. The U.S. iron ore industry faced problems of excess capacity, rising costs of production and transport, and nearly static productivity and declining markets; most of these problems reflected similar problems in the domestic iron and steel industry. The demand for iron ore was expected to decline at an annual rate of 2 percent through 1990.

Iron and steel scrap is an important aspect of the steel and ferrous casting industries. Production in 1984 included 30 million short tons (st) of home-scrap and 46.5 million short tons of purchased scrap (one short ton equals 2,000 pounds). Imports for consumption amounted to .6 million short tons while exports for consumption amounted to 8.2 million short tons. Approximately 78 percent of domestic scrap consumption was for steel products; 21 percent was for the ferrous casting industry; and relatively small quantities were used for other purposes. Demand for ferrous scrap is expected to increase at an annual rate of 2.8 percent through 1990.

An estimated 20 million tons of iron and steel slags, byproducts of iron and steelmaking, were produced annually in 1983 and 1984. These slags are typically used as road-base material and are consumed mainly by the construction industry.

Raw steel production in 1984 was estimated at 93 million short tons and apparent consumption was estimated at 100 million short tons. From a 1981 base, demand for steel is expected to increase at an annual rate of about 1.1 percent through 1990. Raw steel production in 1983 in the Soviet Union was estimated at 168 million short tons as compared to U.S. production of 85 million. In the United States end use distribution of domestic iron and steel consumption in 1984 was estimated as follows: construction, 31 percent; transportation, 27 percent; machinery, 19 percent; appliances and equipment, 7 percent; and other, 16 percent. Of about 300 companies in the steel industry 92 produce raw steel, and steel plants are located in 39 states. Indiana, Ohio, Pennsylvania, Michigan, and Illinois account for 70 percent of the total output.

For purposes of study and analysis the steel industry may be divided into two segments: integrated and specialty. The integrated industry, which makes carbon steel, accounted for more than 85 percent of the tonnage produced. Competitive steelmaking technology recently in the spotlight in the integrated segment includes electric steelmaking continuous casting, ladle metallurgy, and continuous heat treating lines. Electric furnaces, which account for about one-third of total steel output, are becoming increasingly important. Continuous castings, accounting for one-third of all semifinished steel production in 1983, is moving forward and has spurred the utilization of ladle metallurgy. Used together these technologies are making production more efficient. Research and development is underway to develop automatic process controls and modernize the steel industry in order to make it more competitive. One informed spokesman expressed the belief that the integrated steel industry "needs restructuring to incorporate all available blast furnace technology and productivity standards."[5]

The specialty steel industry's products include stainless steel, tool and die steels, and special alloys with high temperature, electrical, magnetic, and refractory properties. In the United States the specialty steel industry is more technologically advanced, and also more competitive worldwide, than its carbon steel counterpart. Specialty products accounted for about 1.5 percent of all steel consumed in the United States and for almost 10 percent of all domestic steel sales. Ideally, the effectiveness of a 4-year import restraint program, including quotas and tariffs and put into effect by President Reagan in mid-1983, will help the specialty steel industry to modernize and invest in new facilities.

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[5] Quoted is Harry E. Chandler, "The Steel Industry: Present and Future," *Metal Progress*, October 1984, p. 41. Much of the information on the integrated and specialty steel industries in this section is from this article by Chandler.

Indications are that the U.S. steel industry will continue to meet stiff competition and will require unrelenting effort through the 1980s to maintain its position. Industry representatives hold differing opinions about the future; however, many agree that mergers in the steel industry will probably increase the average size of companies and that the trend will be for companies to concentrate on products where they have the greatest expertise. There may be fewer grades of standard steels. Looking forward to the 1990-1995 period, anticipated changes in the specialty steel industry are not expected to be as great as those anticipated for the integrated and minimill segments. The carbon steel industry is expected to continue its modernization and by 1995 the number of manhours per ton is expected to be reduced by 30 to 40 percent. Minimills are expected to experience substantial expansion, perhaps by more than 30 percent by 1995. Opinions vary on the future of the specialty steel industry, but some predictions call for a substantial reduction in the number of companies, numbering 16 in 1984. Third World countries are expected to become an increasing factor in the production of garden-variety steels. If Third World competitors do not get backing from their governments, in the form of subsidies or other support, they are not considered to be a menacing threat.

Chromium

Chromium, one of the most versatile minerals, has important uses as an alloying element, although it is better known as a plating material for automobile accessories, bathroom fixtures, and the like. Chromium in the purest form is produced in limited quantities by vapor deposition from anhydrous chromium iodide. Chromium is found primarily in chromite. The United States is one of the world's leading consumers of chromium. In 1984 end use was as follows: stainless and heat-resisting steel, 81 percent; full-alloy steel, 9 percent; super alloys, 3 percent; and other alloys, 7 percent.

No chromite has been mined in the United States since 1961 and heavy reliance is placed on imports, mostly from the Republic of South Africa, which furnished 55 percent of imports from 1980 to 1983. About 99 percent of world resources for chromium are in southern Africa, with over 83 percent in the Republic of South Africa alone. Most of U.S. chromium resources are in Montana and Oregon, but mining in the near future is doubtful.

U.S. consumption annually from 1980 to 1984 ranged from 319,000 to 587,000 short tons. During this period net import reliance ranged from 76 to 91 percent each year.

The status of the stockpile at the end of November 1984 was as shown in table 5. In 1984, after approximately 125,000 tons of chromite in the stockpile were converted to high-carbon chromium, the General Services Administration (GSA) solicited bids to convert an additional 142,000 tons of chromite to high-carbon ferrochromium in 1985.

The possibilities for substitution for chromium include: nickel for plating, iron for pigments, and boron for alloying. Magnesite may substitute for chromite in refractories.

Manganese

Manganese is essential for the production of virtually all steels, and the demand for it in the United States and elsewhere varies directly with steel production. Manganese also is important in the production of aluminum and cast iron. About 14 pounds of manganese are required for every ton of steel, mainly to desulfurize the steel and to give it greater hardness and strength.

End users of manganese in 1984 were: construction, 23 percent; transportation, 19 percent; machinery, 14 percent; and other, 44 percent. U.S. apparent consumption of manganese for 1985 was estimated at 800,000 tons. Net import reliance as a percent of U.S. consumption in recent years has been 98 to 99 percent. Worldwide, manganese continued in 1984 to be in oversupply. The Republic of South Africa has about 71 percent of the world resources of manganese and the Soviet Union has about 20 percent. The United States has no manganese resource base and its mine production is zero.

The stockpile contains different type materials containing manganese. The GSA was selling chemical ore and battery ore in 1984. At the same time, contracts were being made to upgrade 100,000 tons of stockpiled ore into high-carbon ferromanganese to improve stockpile readiness and to maintain domestic ferroalloy capacity.

The main source of imports is the Republic of South Africa, which from 1980 through 1983 supplied 31 percent of manganese ore and 39 percent of ferromanganese. There is no satisfactory substitute for manganese in its major applications and, therefore, the United States will have a continuing need for imports.

Tungsten

The unique high-temperature properties of tungsten are likely to increase demand for it in all of the three predominant end-use forms: carbides, ferroalloys, and metal. The extreme hardness and wear resistance of tungsten and its alloys at high temperatures yield electrical and thermionic properties that make the metal and alloys particularly useful as important structural materials in nuclear and space applications. End

TABLE 5. STATUS OF U.S. STOCKPILE, 1984
(in thousands of short tons gross weight)

Material	Goal	Total inventory	Average chromium content	Excess to goal authorized for disposal	Sales, 11 months
Chromite:					
Metallurgical-grade	3,200	1,957	28.6%	-	-
Chemical-grade	675	242	28.6%	-	-
Refractory-grade	850	391	-	-	-
Chromium ferroalloys:					
High-carbon ferrochromium	185	402	71.45%	-	-
Low-carbon ferrochromium	75	300	71.4%	-	-
Ferrochromium-silicon	90	57	42.9%	-	-
Chromium metal	20	4	-	-	-

In addition to data shown, the stockpile contained 531,219 tons of metallurgical-grade chromite and 20,762 tons of chromium ferroalloys.

SOURCE: U.S. Bureau of Mines, *Mineral Commodities Summaries 1985* (Washington: Government Printing Office, 1985), p. 33.

uses of tungsten as reflected in data for 1984 were: metalworking and construction machinery, 75 percent; electrical machinery and equipment, 9 percent; lamps and lighting, 9 percent; transportation, 5 percent; and other, 4 percent.

Net import reliance ranged from 42 to 71 percent of apparent consumption from 1980 to 1984. In the period 1980 through 1983 imports were provided as follows: Canada, 19 percent; China, 17 percent; Bolivia, 14 percent; and other, 50 percent.

The United States has less than 10 percent of the world tungsten reserves, while almost 55 percent are located in the People's Republic of China. For 1984 U.S. production of tungsten was estimated at 2,500 tons. Consumption was estimated at 6,000 tons.

In 1984 the GSA continued to offer tungsten concentrate in excess of stockpile needs for sale at a rate of 6 million pounds per year. Under conditions where there might be shortages, titanium carbide, tantalum carbide, and columbium carbide can be substituted for tungsten in some wear-resisting applications. Molybdenum tool steels and tungsten tool steels can be substituted for each other. In many cutting tool applications, depending on factors such as material, feed speed, and depth of cut, some economical substitutes for tungsten carbide are bulk ceramics and coatings of carbides, nitrides, carbonitrides, and alumina on tungsten carbide inserts.

Even with improved technology to process tungsten ore, the United States will be dependent upon imports and Government sales to maintain a balanced supply-demand relationship.

Nickel

The greatest value of nickel is as an alloy because of its capability of adding strength and corrosive resistance over a wide range of temperatures. It plays a key role in the iron and steel industry and the aerospace industry. Alternate materials are available to take the place of nickel in essentially all its uses. With few exceptions, however, using alternate materials would increase costs or require some sacrifice in the physical or chemical characteristics that nickel contributes and, consequently, would affect the economy or performance of the product.

The estimated domestic mine production of nickel in 1984 was 7,500 tons, and U.S. consumption was estimated at 200,000 tons. The net import reliance as a percent of consumption was about 76 percent from 1980 through 1984. Canada, which furnished 38 percent from 1980 through 1983, has been the chief source of imports. The United States has less than 3 percent of world nickel resources, and its production is relatively small because of low-grade ore and relatively poor market conditions. World resources of nickel are large and include deep-sea deposits, and nickel is the most valuable constituent of the nodules from the seabed. The largest reserve bases are found in New Caledonia, Canada, other market economy countries, and Cuba. Of the identified world resources about 80 percent of the nickel is in laterites and 20 percent is in sulfide deposits.

The major end uses of nickel in 1984 were: transportation, 24 percent; chemical industry, 16 percent; electrical equipment, 11 percent; construction, 10 percent; fabricated metal products, 9 percent; petroleum and household appliances, 8 percent each; and machinery and other, 7 percent each.

With few exceptions, substitutes for nickel would result in increased cost or some sacrifice in the economy or performance of the product. Present and potential nickel substitutes include aluminum, coated steel, and plastics in the construction and transportation industries; nickel-free specialty steels in the power generating, petrochemical, and petroleum industries; titanium and plastics in severe corrosive applications; and platinum, cobalt, and copper in catalytic uses.

At the end of November 1984 the stockpile goal was 200,000 tons of nickel and the total inventory was 32,209 tons. In an emergency, supplies of nickel from Canada coming overland seem to be assured, but those from other countries would be subject to the hazards of wartime ocean shipping.

MAJOR NONFERROUS METALS

Aluminum

Demand for aluminum and its components has grown at a faster rate worldwide than the demand for other major metals. Annual consumption in the United States has ranged from 4.8 to almost 5.3 million tons from 1980 to 1984 and primary production has ranged from 3.4 to 4.7 million tons during the same period. Plant capacity for aluminum production is 4.9 million tons annually. Net import reliance as a percent of consumption has ranged from 0 to 17 percent during the period. Canada furnishes more than 60 percent of imports. The trend appears to be toward greater reliance on imports.

Aluminum is produced by approximately 12 companies operating 27 primary aluminum reduction plants, with three firms accounting for 57 percent of production in 1984.

The largest use of aluminum was packaging, taking 35 percent of domestic consumption in 1984. Other users were: transportation, 20 percent; building, 18 percent; electrical, 9 percent; consumer durables, 8 percent; and other use, 10 percent.

There are substitutes for aluminum in many applications. Copper can be used for electrical applications, while magnesium and titanium may be used for structural and transportation purposes. Steel may be used when weight saving is not important. Composites, wood, and steel may be used in the building and construction markets, and glass, plastics, paper, and steel may be used in the packaging market.

Bauxite, the main ore of aluminum, is plentiful worldwide. The largest resource bases are in Guinea and Australia. Approximately 95 percent of aluminum raw materials are imports. U.S. production of bauxite in 1982 and 1984 was only about 890,000 metric tons. U.S. reserves of good quality bauxite are very small, but subeconomic raw materials such as clays, alunite, and others are virtually inexhaustible sources for aluminum.

At the end of November 1984 the stockpile goal for aluminum was 700,000 tons, but the inventory was only 2,000 tons. The status of bauxite stockpiles (in thousand metric dry tons) was as shown in table 6. The stock of metal grade bauxite was increased in 1983 and 1984 by acquisitions from Jamaica.

It is anticipated that demand for aluminum will continue to be strong throughout the 1980s. The 11-member International Bauxite Association accounted for 70 percent of world bauxite production in 1983. Closure of bauxite mines in the Caribbean area in the early 1980s left one mine in Jamaica as the only producer in that region.

TABLE 6. STATUS OF BAUXITE STOCKPILES

Material	Goal	Total inventory
Bauxite-abrasive grade	1,016	
Bauxite-metal grade:		
Jamaica type	21,337	10,638
Suriname type	6,198	5,385
Bauxite-refractory grade, calcined	1,422	203

SOURCE: U.S. Bureau of Mines, *Mineral Commodities Summaries 1985* (Washington: Government Printing Office, 1985), p. 17.

Copper

Copper, one of the most important materials in the advancement of industrial societies, has been in use for 6,000 years. It is closely linked with the age of electricity, and more recently, with cupronickel alloys, particularly in marine and desalination applications.

The United States, a leading producer and consumer of copper, produced 1 to 1.5 million tons from 1980 to 1984 and consumed 1.7 to 2.3 million tons annually during the period. The United States has the capacity to produce well above the level of output for the early 1980s. In 1984, 31 mines accounted for 99 percent of the 1 million tons produced, and many mines remained closed because the strength of the U.S. dollar placed U.S. producers at a disadvantage. Cost-saving efforts are being made, however, to improve the competitiveness of the U.S. copper industry. Net import reliance in the early 1980s ranged from 1 to 21 percent. From 1980 to 1983 Chile furnished 42 percent of imports and Canada, the second largest supplier, 24 percent.

The main uses of copper as reflected in data for 1984 are: building construction, 34 percent; electrical and electronic products, 24 percent; industrial machinery and equipment, 16 percent; transportation, 12 percent; and consumer and general products, 14 percent. If necessary, other materials may substitute for copper in some applications; examples are: aluminim in electrical equipment and in heat exchangers; steel in shell castings; optical fiber in the communications cable; and plastics in plumbing drains.

The United States has a good copper resource base, with over 17 percent of the world total. The market economy countries, including the United States, have about 85 percent of land-based copper resources. Copper resources in deep-sea nodules are estimated at .7 billion tons and later may be a significant market factor.

The stockpile goal for copper at the end of 1984 was 907,000 tons, and the inventory was 20,000 tons.

Lead

Lead is one of the oldest metals used by people, and it continues to be one of the most essential. Today, its uses, as indicated by data for 1984, are transportation (batteries, gasoline additives, and others), 75 percent of the total consumption; construction, paint, ammunition, and electrical applications, 22 percent; and the remainder for ceramics, glass, type metal, and other. Substitution by plastics has reduced the use of lead in building construction, electrical cable covering, and in cans and containers. Aluminum, tin, iron, and plastics compete with lead in other packaging and protective coatings.

The United States has produced annually during the past 5 years from 446,000 to 550,000 tons, and annual consumption has been approximately 1 million tons. Import reliance has been relatively low, at 0 to 18 percent annually. Seven mines in Missouri, of a total of 12 in production, supplied 87 percent of the total output. Refinery capacity utilization in the lead industry during 1983 was 67 percent in the primary sector but only 44 percent in the secondary sector, which produces recycled metal and about half of total production in recent years.

Since lead may be a hazard to health, problems are incurred in its production and use. On 1 July 1984, final effluent limitations under the Clean Water Act became effective for all nonferrous metals and battery manufacturing plants. On 1 August, all lead smelters and battery plants were required to submit final compliance plans for the 1979 Occupational Safety and Health Administration lead standard. In August, the Environmental Protection Agency announced that the permissible amount of lead in gasoline would be reduced by over 50 percent on 1 July 1985, and by over 90 percent on 1 January 1988, from the present standard. A total ban by 1995 was being considered.

The United States has about one-sixth of the world resource base of lead and in 1983 produced more than 13 percent of world output. Moreover, in recent years major economic and marginal economic resources of lead have been discovered in the United States, Canada, Australia, and the Republic of South Africa. The identified subeconomic lead resources of the world are estimated at about 1.4 billion tons. Much of this resource is in low-tenor or unconventional deposits that need new technology for development and recovery, but the prospect for finding additional resources of conventional deposits at a rate exceeding consumption is highly favorable.

The stockpile inventory was 545,000 tons at the end of 1983, and the goal was 998,000 tons.

Zinc

Zinc, an exceedingly versatile and essential metal in many modern devices, is widely used and in large quantities. Its wide use during 1984 was as follows: construction materials, 45 percent; transportation, 25 percent; machinery, 11 percent; electrical, 9 percent; and other, 10 percent.

Consumption of zinc in all forms in 1984 was slightly over 1 million tons. From a 1981 base, domestic demand for zinc was forecast to increase at an annual rate of 2.2 percent through 1990.

Mine production in 1984 was 265,000 tons and about two-thirds of supplies came from imports. Since 1980 annual imports have ranged from 58 to 67 percent of consumption. The United States has a large reserve base of 53 million tons, out of a world total of 290 million tons. The 25 leading mines accounted for 98 percent of output in 1984 with the top five producing 54 percent. Tennessee, New York, and Missouri produced about 85 percent of mine output. Production could be increased using existing capacity. Canada has a reserve base of 53 million tons and other countries in the West and Australia have large quantities of zinc. Canada furnished 59 percent of U.S. imports from 1980 through 1983.

Zinc prices rose after price controls were lifted in 1973 and have remained about double the level of the period 1954 to 1973 when they ranged from 10.7 cents per pound to 20.7 cents. The average price of high grade metal in 1984 was 48 cents per pound.

The total stockpile inventory of zinc at the end of November 1984 was 343,000 tons and the stockpile goal was 1.293 million tons.

Aluminum, plastics, and magnesium are the major substitutes for zinc in diecasting. Plastic coatings, paints, electroplated cadmium, and aluminum-zinc coatings can replace zinc in limited areas for corrosion protection, and aluminum alloys can be used in place of brass. Aluminum, magnesium, titanium, and zirconium are significant competitors of zinc in chemicals and pigments.

Tin

Tin is used in many ways, usually in improving the properties of other materials that touch our daily living. It is used in castings for steel cans and containers, and in solders for joining pipes or electrical conductors, and in other alloys for widely diversified applications. In 1984, when consumption totaled 51,800 tons, the major uses were: cans and containers, 21 percent; electrical, 18 percent; construction, 14 percent; transportation, 14 percent; and other, 33 percent.

Net U.S. import reliance in the early 1980s was approximately 75 percent. The largest suppliers from 1980 to 1983 were: Thailand, 30 percent; Malaysia, 23 percent; Indonesia, 16 percent; and Bolivia, 15 percent. U.S. mine production is negligible, but almost one-fourth of the total consumption is derived from secondary material. U.S. tin resources, located primarily in Alaska, are insignificant. The U.S. reserve base is 40,000 tons in a world total of 3 million tons. Countries with the largest reserve base are Malaysia with 1.1 million tons and Indonesia with .68 million tons. In the mid-1980s there continued to be a large worldwide excess of supply relative to demand. With an excess in its stockpile of nearly 20,000 tons at the end of 1984, the United States sold tin despite objections from the International Tin Council, of which it is not a member.

Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers; epoxy resins for solder; aluminum alloys, copper-base alloys, or plastics for bronze; and lead-base bearing alloys or plastics for tin-containing bearing metals.

VII

STRATEGIC AND CRITICAL NONFUEL MINERALS

U.S. VULNERABILITIES

U.S. dependence on foreign sources for strategic and critical nonfuel minerals has caused much concern about our vulnerabilities in case of a national security emergency. Some maintain that the Nation's dependence poses serious risks and dangers; others, also aware of the situation, see vulnerabilities but not of critical importance. Strategic and critical materials, as defined in the Strategic and Critical Materials Stockpiling Revision Act of 1979, are those that would be needed to supply the military, industrial, and essential civilian needs of the United States during a national defense emergency; and they are not found or produced in the United States in sufficient quantities to meet such needs. The President is authorized to determine which minerals are strategic and critical and the quantity and quality of minerals to be stockpiled for use in a national emergency.[1]

The most commonly used definition of potential availability problems is an estimated percentage of U.S. consumption (in 1985 more than 50 percent) that is satisfied by important supplies. Using this definition, the United States has potential vulnerability problems in at least 23 of the 46 nonfuel mineral markets deemed essential to an industrialized economy. Relatively insecure sources that are subject to supply disruptions include Communist-bloc countries and countries in southern Africa. These countries supply three-fourths or more of our requirements for cobalt, chromium, and platinum and 40 to 50 percent of manganese. (*figure 4*) Other minerals that may be vulnerable to supply disruptions include rutile (titanium ore), columbium, bauxite (aluminum ore), tantalum, tin, and tungsten. While the list of minerals vulnerable to potential supply disruptions may vary somewhat depending on the criteria used for their selection, manganese, cobalt, chromium, and platinum are usually at the top of the list because the United States must import almost 100 percent of all it consumes of these metals.

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[1] Major sources for information in this chapter are: John T. Guttman, Colonel, USAF; Victor J. Fenwick, Jr., Lieutenant Colonel, USA; John F. Graham, Defense Mapping Agency; and Joseph E. Merrick, Colonel, USAF, *Critical Non-Fuel Minerals in Mobilization with Case Studies in Cobalt and Titanium* (Washington: Industrial College of the Armed Forces (unpublished report in the Mobilization Studies Program) April, 1983); U.S. Bureau of Mines, *The Domestic Supply of Critical Minerals* (Washington: Government Printing Office, 1983); Allen F. Agnew, ed., *International Minerals: A National Perspective* (Boulder, Colo.: Westview Press, 1983); and Robert A. Kilmarx, *Toward a Coherent U.S. Policy on Strategic Minerals*, Volume IV, number 3, Significant Issues Series (Washington: Center for Strategic and International Studies, Georgetown University, 1982).

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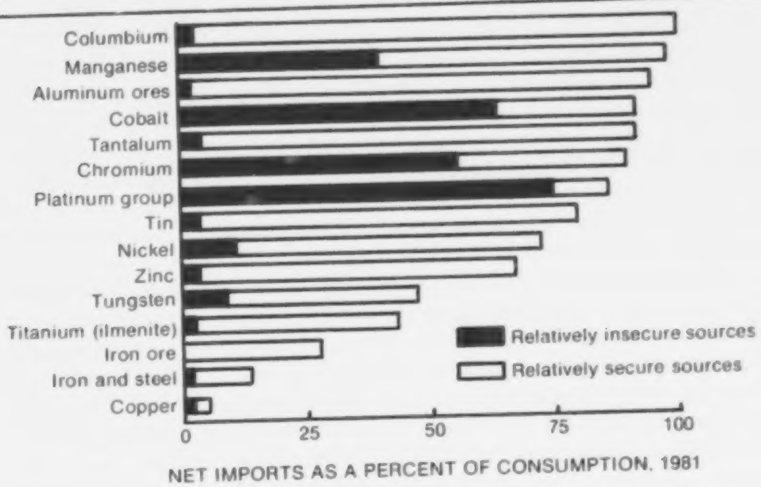

FIGURE 4. MINERAL IMPORT DEPENDENCY

SOURCE: U.S. Bureau of Mines, *The Domestic Supply of Critical Materials* (Washington: Government Printing Office, 1983), p. 30.

Perceptions of vulnerability vary considerably because different frameworks are used for making analyses and opinions vary on the reliability of foreign suppliers. Alarmists see the combination of high Western dependence and the Soviet Union's expanding mineral needs as a cause for Soviet moves to control southern Africa, the primary source of minerals critical to U.S. weapons production. Others do not agree. Michael Shafer was of the opinion that "dependence on imports from southern Africa and the problem of continual access to mineral supplies do not pose immediate critical or strategic threats to the United States and its allies."[2]

The U.S. General Accounting Office, in reports relating to critical minerals and materials in 1981 and 1982, points out that "high U.S. import reliance is not synonomous with vulnerability and does not necessarily present a high risk to the U.S. economy or a national energy program."[3]

While analysts are not in agreement as to what constitutes vulnerability, principal criteria that need to be considered are:

—Is there a critical need in either defense or in the industrial economy?

—Are adequate domestic resources lacking, and are there prospects of finding any?

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[2] Michael Shafer, "Mineral Myths," *Foreign Policy*, Summer 1982, p. 155.

[3] The U.S. General Accounting Office, *Actions Needed to Promote a Stable Supply of Strategic and Critical Minerals and Materials* (Washington: U.S. General Accounting Office, 1982), p. 5.

–Are substitutions possible?

–Are alternative and more secure supply sources lacking?

The absence of capabilities to process materials may contribute to the level of vulnerability in a particular metal. In the long term several approaches may reduce the level of vulnerability, including stockpiling, substitution, conservation in use, reuse (recovery and recycling), and increased domestic supply. Critical factors include the cost of the potential loss to the U.S. economy and national priorities and the availability of market-related incentives such as substitution and conservation. Persons who take the alarmist viewpoint tend to perceive a need for Federal intervention to guarantee an adequate flow of nonfuel minerals deemed critical to the U.S. economy or national priorities such as defense. Those who feel less threatened tend to rely on a free market system, operated by private enterprise with minimal Federal Government interference–a system that meets and is believed to be able to continue to meet U.S. industrial needs.

U.S. economic well-being and national security are critically dependent on the current and future availability of nonfuel minerals, particularly such widely used ones as manganese, cobalt, chromium, and the platinum group of metals from foreign sources. E. F. Andrews, Vice President for Materials and Sources of Allegheny International, observed that without chromium and cobalt "we could not build a jet engine, build an automobile, run a train, build an oil refinery, or build a nuclear or conventional power station. . . . We could not build a computer, cutting tool, mine tool, magnet, or process crude oil, just to mention a few things."[4] The use of strategic and critical nonfuel minerals is illustrated in the materials required for the construction of the F-100 turbofan engine, which powers the F-15 and F-16 fighter aircraft, as follows: 5,479 pounds of titanium, 4,597 pounds of nickel, 1,537 pounds of chromium, 886 pounds of cobalt, 715 pounds of aluminum, 163 pounds of columbium, and 3 pounds of tantalum.[5]

Net import reliance and major sources of selected nonfuel minerals are shown in figure 5. While overall U.S. mineral import reliance is about 25 percent, foreign sources supply 40 percent of our unprocessed metallic mineral needs. U.S. reliance on foreign sources is highest, in combined total value, for iron ores and other ferrous minerals such as chromium, manganese, nickel, and columbium. In combined total value over a third of nonferrous minerals such as copper, aluminum, and zinc are supplied by imports.

The Soviet Union, in contrast to the high dependency of the United States, has the capability to be self-sufficient, or nearly so, in nonfuel

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[4] Quoted by James A. Miller, "Hard Choices," *Seapower*, April 1984, p. 103.

[5] John D. Morgan, *Strategic Minerals* (Washington: U.S. Bureau of Mines, March 28, 1984), p. 9.

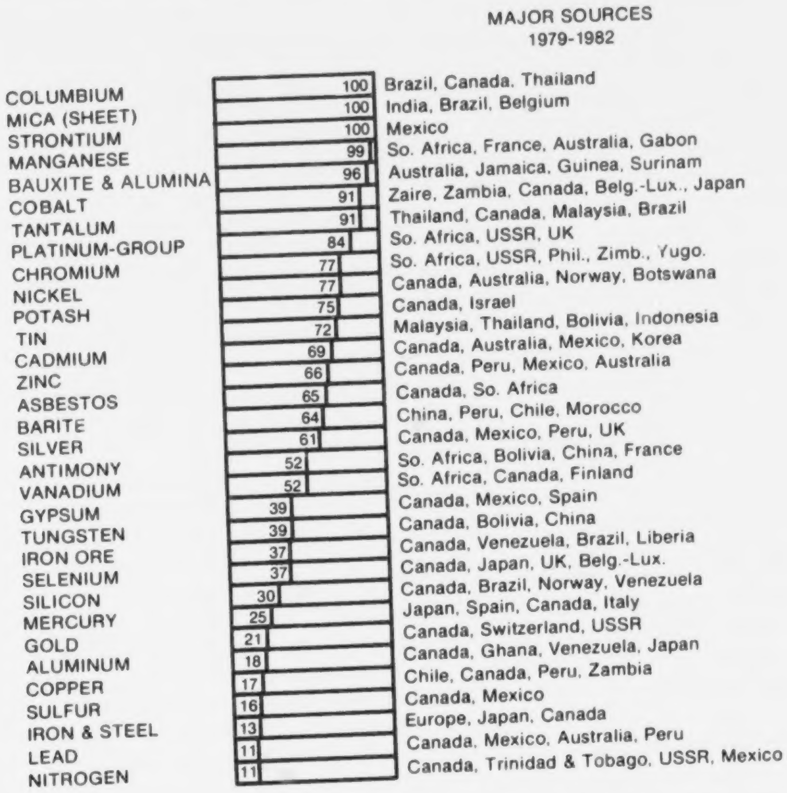

FIGURE 5. U.S. NET IMPORT RELIANCE: 1983 SELECTED NONFUEL MINERAL MATERIALS

SOURCE John D. Morgan, *Strategic Materials* (Washington: U.S. Bureau of Mines, March 28, 1984), p. 28.

minerals. Because of economic or other considerations the Soviet Union in recent years has found it expedient to import various nonfuel mineral materials. They attempt to sell the minimum amount of materials for maximum prices. Generally, mineral exports are not surpluses and could easily be consumed in the Soviet domestic economy. Petroleum and gold have been the traditional mainstay of hard currency earnings of the Soviets, but natural gas has become increasingly important in recent years. Price increases on certain metals such as the platinum group have caused the Soviets to make sales at opportune times. Soviet mineral imports in the mid-1980s included bauxite and aluminum, cobalt, tin, borite, and tungsten.

The Soviets have been attempting to develop a viable oil and strategic minerals denial strategy either through physical disruption, market manipulation, or control of producing states and strategically important land and sea areas. In 1973 Leonid Brezhnev, the Soviet premier, indicated that it was the Soviet goal to control the two great treasure houses on which the West depends, the oil of the Persian Gulf and the minerals of southern Africa. Soviet support of Marxist insurgencies in southern Africa and other resource-rich countries in recent years tends to support the credibility of Brezhnev's statement. The Soviet major politico-military successes in Africa are seen in Angola, Mozambique, and Ethiopia—countries that signed treaties of friendship and cooperation with Moscow in 1976, 1977, and 1978, respectively. Cuba and East European allies of the Soviets have rendered valuable services in Africa as combatants, advisers, and experts. While the Soviets are aware of the value of the areas where they have influence, they recognize the precarious conditions under which their clients prevail.

While the majority of U.S. mineral imports comes from reliable sources, insecure sources, including centrally planned economies, account for about 10 percent of raw and processed U.S. imports. We are dependent on southern Africa and the centrally planned economy countries for 75 percent of our manganese, cobalt, chromium, and platinum, which are essential for steelmaking and other high technology uses. In a recent representative year the United States obtained from southern Africa 93 percent of the platinum group metals, 76 percent of the cobalt, 48 percent of the chromium, and 44 percent of the manganese it needed. West European and Japanese dependence on southern Africa for these four and other minerals is even higher than that of the United States. The argument that a Marxist-controlled southern Africa would have to sell its manganese, cobalt, chromium, and platinum to the West to sustain the economy does not seem to stand up; in southern Africa these four commodities account for less than 10 percent of the total annual export sales of the minerals industry.[6]

However, the dependence of southern Africa, and particularly of the Republic of South Africa, on foreign markets for its minerals is also significant. In 1985 U.S. markets for the products of the Republic of South Africa's mineral industry were probably more important to that country than were the mineral exports from the Republic of South Africa for the United States. Only about 15 percent of minerals produced in the Republic of South Africa are consumed domestically and the rest are exported. On the other hand, South Africa's critically important position on strategic sealanes must be recognized. Some 25,000 ships pass around the Cape of Good Hope each year; they carry more than three-fourths of Western European oil and two-thirds of Western Europe's strategic minerals as well as much of U.S. oil imports from the Persian Gulf.[7] Apartheid in the Republic of South Africa continues to complicate relations between that nation and the United States and has a pejorative influence on economic relationships that otherwise would flourish.

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[6] Miller, "*Hard Choices*," pp. 104-105.

The large percentages (as shown in *table 7*) of the world reserve bases of chrome, cobalt, manganese, and the platinum group located in the centrally planned economies (CPE) and southern Africa are discomforting.

TABLE 7. PERCENT OF RESERVES IN CENTRALLY PLANNED ECONOMIES AND SOUTHERN AFRICA

Metal	Percent in CPEs	Percent in southern Africa
Chromite	2	89
Cobalt	13	37
Manganese	22	75
Platinum group	17	81

The trend toward government ownership of mining in the Third World – frequently accompanied by a decline in the operation of market forces – gives U.S. policymakers reason for concern. Moreover, supplies of nonfuel minerals from southern Africa and the Third World may be subjected to nonmarket barter, price manipulation, expropriation, nationalization, or sabotage. Third World nations, many of which are embittered by the legacy of past colonialism, are campaigning for economic reform that has come to be known as the New International Economic Order. This development, embracing more than a hundred nations, has the potential for changing trade relationships between developed and developing countries.

In the first half of the 1980s most metals and minerals were international commodities in that only a few cents per pound moved them physically in the major markets of the world. About two-fifths of the world's iron ore, bauxite, aluminum, and copper and almost one-fifth of the world's steel and aluminum moved in world trade. World markets for both mineral raw materials and manufactured articles were becoming more competitive. Under the conditions that prevailed in this period the United States was able to get needed supplies of strategic and critical nonfuel minerals without great difficulty.

Examples may be cited from the past successes in obtaining adequate supplies of special property materials for defense purposes. Dr. John D. Morgan, a long-time specialist on strategic materials, gave the following illustrations at an Industrial Materials Information Symposium in 1984[8]: In the late 1940s columbium and tantalum—high temperature metals—were of particular importance to the emerging jet engine programs. Prior to the Korean War, U.S. and allied studies concluded that only one million pounds per year could be produced worldwide. Nevertheless, early in the Korean War a worldwide 100 percent bonus program under Title III of the Defense Production Act resulted in such an expansion of supply that in only 3 years the U.S. stockpile alone acquired 15 million pounds meeting specifications, while additional supplies were also available for current uses. At the start of the Korean War large quantities of tungsten were needed for high-velocity armor-piercing projectiles. Domestic mine production was then only half of normal U.S. industrial needs and the other half came from imports, largely from China. A Defense Production Act domestic purchase program at $63 a short ton unit (about four times the previously prevailing price) quadrupled domestic mine production of tungsten in 2 years. This increase more than filled stockpile goals so that the U.S. Government sold surplus tungsten for many years, sometimes at prices as much as double what it paid. Titanium metal, although twice as heavy as aluminum, is six times as strong. A titanium expansion program during the Korean War in a few years created a viable domestic titanium metal industry through guaranteed contingent procurement contracts under Title III of the Defense Production Act. Titanium metal was thus made available for military airplanes and ships and for chemical industry applications. Later, similar metallurgical processing technology was utilized to develop zirconium for nuclear reactors for military and civilian applications.

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[7] American African Affairs Association, Inc., *Struggle for Survival: Strategic Minerals and The West* (Washington: American African Affairs Association, 1980), p. 28.

U.S. experience with cobalt during the past decade serves to illustrate how anxiety about vulnerability may influence U.S. actions and prices of a particular metal. Cobalt, a mineral for which the United States was almost 95 percent dependent on imports in the early 1980s, was one of 11 materials designated as "priority" by President Reagan in 1981. Cobalt is used in jet engines, cutting tools, drill bits, wellhead valves, and as a catalyst for petroleum hydrogenization because it has desired properties of hardness and resistance to corrosion, heat, and abrasion.

Half of U.S. cobalt imports came from Zaire (37 percent) and Zambia (12 percent) from 1980 to 1983. The United States has about 10 percent of world reserves of cobalt, but production has not been economical. Minor production ceased at the end of 1971 and despite renewed efforts has not been revived. Almost invariably cobalt is recovered as a byproduct of copper and nickel mining. Cobalt is usually less than 3 percent of the combined copper and nickel ore. Only when the price of cobalt is sufficiently high does it become a coproduct rather than a byproduct. Consequently, the production of cobalt may become highly dependent on the prices of copper and nickel.

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[8] Industrial Materials Information Symposium, Department of Defense, Joint Aeronautical Materials Activity (JAMAC), Wright-Patterson Air Force Base, Dayton, Ohio, December 5, 1984.

The invasion by Soviet-supported Katangan rebels living in Angola into the Shaba province of Zaire in 1977 and 1978 had great significance for the world cobalt market. It caused alarm among Americans who feared expansion of Soviet influence in southern Africa. Domestic factors in the United States also entered into the scare of a cobalt shortage. From 1968 to 1976 the Federal Government sold 6 to 9 million pounds of cobalt each year, almost one-half of annual consumption. Sales were suddenly stopped in 1976, and a new policy that entailed the doubling of the cobalt stockpile was announced. This policy reversal caused an almost immediate domestic shortage of cobalt. U.S. industries that were partially dependent on stockpile sales suddenly had to seek new sources and to some extent became competitors with the Government. At the time of the invasion of Shaba province, that area was providing more than half of both the world's and U.S. imports of cobalt. There were rumors that the Soviet Union had purchased large supplies of cobalt just prior to the Katangan invasion. Cobalt prices rose from $6.40 per pound in early 1978 to more than $25 per pound by the end of the year, with occasional spot prices on the open market reaching $50 per pound. Anticipated shortages, speculative buying, and panic hoarding contributed to the jump in cobalt prices.

The facts of the 1978 environment in Zaire were that only minimal damage had been inflicted on the mines that were shut down for weeks, but the massacre and exodus of civilian technicians and disruptions in transportation facilities had an adverse impact on production. Evidence of large Soviet purchases of cobalt has not been found. Because of logistical and political problems related to land transportation, Zaire has had to use air transportation for a significant share of its cobalt exports since 1978.

There were concerns that Zaire and Zambia, producers of 75 percent of mine output of cobalt, might collude; instead, in the early 1980s, both countries have offered cobalt at attractive prices. The sale by Zaire of cobalt for the U.S. stockpile in 1981 was at the rate of $15 per pound, compared to the then-prevailing producer price quote of $20 per pound. In October 1982 Zaire again offered to sell the U.S. 2,000 tons of cobalt at a price of $5.80 per pound while the current price had been $12.50 per pound since February 1982. Zaire's intention may have been an effort to protect its market share from inroads by Zambia, the world's second largest producer; however, it also had a detrimental effect on any plans U.S. private industry may have had for further domestic cobalt development.

The U.S. stockpile goal for cobalt in 1985 was 42,700 tons. With the purchase of 3,250 tons from Zaire and Zambia in 1983 and 250 tons from a Canadian company in 1984 (with deliveries completed by October 1985), the U.S. inventory would reach 62 percent of its goal. Surplus market conditions were expected to prevail worldwide in 1985 because cobalt supplies have continued to exceed demand.

Cobalt resources in the United States are estimated at 1.4 billion pounds. When cobalt prices reached the $25 per pound level in 1978, consideration was given to reopening cobalt mines in Blackbird, Idaho, and in Missouri and California. Planning indicated 66 to 75 percent of total investment costs would be for high priority cobalt refining, including high costs for meeting environmental requirements. Refining of the U.S.-mined cobalt in overseas areas has been considered, but this presents the potential vulnerability of interdiction of sealanes. The best long-term prospect for abundant supplies of cobalt may be the nodules from the ocean floor. Estimates indicate an average deep-sea manganese nodule may yield one-third of 1 percent cobalt, 1 percent copper, and 24 percent manganese.

POLICY

Events beginning with the oil embargo in 1973 and growing U.S. dependency for critical nonfuel minerals caused U.S. policymakers to take steps to reduce U.S. vulnerability. Before discussing recent events, let us look briefly at developments since the early part of the present century when U.S. mineral imports consisted primarily of a relatively few metals that could not be produced in the United States; also those imports usually had limited specialized applications. In the 1920s there was some increase in mineral imports. A few responsible officials believed that the United States should import raw materials in order to preserve scarce domestic resources for emergency use. However, U.S. leaders generally failed to heed the lessons of World War I and the United States was unprepared for World War II. During the 1930s President Franklin Roosevelt personally vetoed proposals for strategic stockpiling. When the Japanese attacked Pearl Harbor, the United States had no cobalt for a 3-year war, only 16 percent of anticipated chromium and manganese needs, and only 28 percent of tungsten requirements. During World War II the United States outgrew its domestic materials base, becoming an importer of 60 minerals, 27 for which there was critical dependence on foreign suppliers. Secretary of the Interior Harold L. Ickes warned that the United States had become a "have-not" power.[9]

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[9] Allen F. Agnew, ed., *International Minerals: A National Perspective* (Boulder, Colo.: Westview Press, 1983), p. 158.

Concern for possible future shortages of strategic and critical materials prompted Congress to pass the Strategic and Critical Materials Stockpiling Act of 1946 (PL 79-520). The basic purpose of this act was to decrease and prevent wherever possible "a dangerous and costly dependence of the United States upon foreign nations for supplies of these materials in times of national emergency."

The stockpile program was only about 25 percent complete in June 1950 when the North Koreans attacked southward. A principal purpose of the Defense Production Act of 1950 (PL 81-774), a second landmark statute, was to provide the basis for defense mobilization efforts and to expand productive capacity, especially of strategic and critical materials. Government acquisition of materials was a subordinate objective. Title I provided specific authority for priorities and allocations, and Title III provided broad authority for expanding supplies of materials—making specific provisions for exploration, development, and mining of strategic and critical minerals and metals, and the development of substitutes. A growing public awareness of the Nation's vulnerabilities during the Korean War helped gain support for stockpiling and domestic resource development. President Eisenhower understood and gave priority to the national security aspects of resource problems, more than any other President since World War I.

By 1954 there were four different inventories of stockpiled materials, some of which did not have any direct relationship to defense requirements. The Agricultural Trade Development and Assistance Act of 1954 provided that surpluses could be sold and credits obtained by this means could be used for several purposes, including the purchase of materials not necessarily related to defense. After Eisenhower, the succeeding three administrations sold stockpiled materials for political and budgetary purposes and as a price stabilization instrument.

Concern about Soviet expansion in the Persian Gulf and southern Africa and increasing U.S. dependence on imports of strategic and critical materials in the 1970s led to enactment of new legislation. The Strategic and Critical Materials Stockpiling Revision Act (PL 96-41), which became law in July 1979, states that the purpose of the stockpile is ". . . to decrease and preclude, when possible, a dangerous and costly dependence by the United States upon foreign sources for supplies of [strategic and critical] materials in times of national emergency," and that the stockpile "should be sufficient to sustain the United States for a period of not less than three years in the event of a national emergency." Under the 1979 act all monies earned from the sale of stockpiled materials are credited to the "transaction fund," and are "available . . . only for the acquisition of strategic and critical materials."

The National Materials and Minerals Policy, Research and Development Act of 1980 (PL 96-479), declared that it is the continuing policy of the United States to promote an adequate and stable supply of materials necessary to maintain national security, economic well-being, and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resource conservation, and social needs. The act required the President to report to the Congress his program plan to implement the provisions of the statute and to include program and budget proposals. Passage of the 1980 act led to the formation of the Cabinet Council on Natural Resources and Environment, which is chaired by the Department of the Interior. Matters relating to national materials policy are coordinated through this Council.

President Reagan sent the first response to the 1980 act to Congress in April 1982 in the *National Materials and Minerals Program Plan and Report.* In this report the President emphasized the critical role of minerals in our economy, national defense, and standard of living. He proposed to diminish minerals vulnerability by allowing private enterprises "to preserve and expand our minerals and materials economy." The President's initiatives, outlined in the report, placed special focus on (1) opening up more public lands to minerals exploration and development, while preserving the environment; (2) improving the Government's capabilities for collecting and analyzing minerals and materials data; (3) upgrading the National Defense Stockpile, which is deficient both quantitatively and qualitatively in a great many of the most critical and strategic minerals; and (4) improving minerals and materials research and development (R&D). The report also cited the responsibilities of the Emergency Preparedness Board, which brings together representatives of more than 20 key Federal departments, agencies, and executive offices at the Deputy or Under Secretary level and is chaired by the Assistant to the President for National Security Affairs to help the people, Government, and economy to work in concert. The President issued National Security Decision Directive number 47 to carry through various provisions of the 1982 program plan.

While the 1982 report outlined initiatives that were recognized as steps in the right direction, many people outside of Government were of the opinion that the administration had not gone far enough and that the plan was not comprehensive. It did not, for example, include measures to reduce the problems of the domestic processing industries, increasing numbers of which were moving overseas and were being replaced by foreign competitors.

Efforts were continuing in 1985 to improve stockpiles of strategic and critical items, including some purchases and some conversions to ugrade materials. Inventories, however, were short of stockpile goals for many minerals, including chromium, cobalt, and the platinum group.

The status of the National Defense Stockpile is discussed in greater detail in the concluding chapter, "Resources for National Emergencies."

Research of a scientific, technological, or economic nature to develop domestic production or substitutes for strategic and critical materials is a continuing part of the stockpile program. Both land areas and offshore locations are being investigated to develop new resources. In response to the President's direction to encourage exploration and production of vital resources in his January 1984 State of the Union message, the Secretary of the Interior ordered appropriate agencies in the Department, including the Minerals Management Service, the U.S. Geological Survey, and the Bureau of Mines, to intensify and coordinate their scientific and research efforts toward a viable offshore minerals program. Research on substitutions, for example, use of low-alumina refractories from domestic sources to substitute for imported high-alumina refractories, is being conducted in several areas.

Scientists from the U.S. Geological Survey and the Bureau of Mines represent the United States in the International Strategic Minerals Inventory (ISMI), a cooperative data-collection effort of earth-science and mineral-resource agencies in Canada, the Federal Republic of Germany, the Republic of South Africa, and Australia. Participating countries are contributing information to a global inventory for selected strategic mineral resources. A summary report of major world manganese resources has been published and reports are planned on other minerals and metals.

The National Defense Stockpile is one answer, but not a complete solution, to the nonfuel minerals import-dependency problem. The Reagan Administration has done well in its efforts to improve the stockpile and make it more responsive to national security needs. However, the lack of competitiveness of U.S. minerals industries has resulted in increased dependence on imports and in many cases the deterioration of capacity to mine or process minerals and metals. The fact that U.S. allies in Western Europe and Japan do not maintain significant strategic stockpiles poses problems. Would the United States feel compelled to come to their rescue if their security were threatened? Events since the 1973-1974 oil embargo have pointed up the significance of natural resources and the importance of obtaining them in peacetime as well as in emergencies. It is unmistakably clear that there must be an explicit provision for resource security in American foreign policy to minimize vulnerabilities and to cope with shortages should they occur. Vulnerability remains high and is likely to continue unless a comprehensive nonfuel minerals policy is adopted that takes into account domestic resources, research and development, defense stockpiling, and regulatory reform. The costs of such a program are high,[10] and public support to attain a reasonably secure supply of minerals for emergencies was not strong in 1985 as attention focused on reductions in the Federal budget to slow the growth of the deficit.

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[10] See chapter X, "Resources for National Emergencies" for costs of materials to reach National Defense Stockpile goals.

VIII

ENERGY

THE ENERGY SCENE

Following more than a decade of public anxiety about future supplies of energy, the American with average income was not particularly concerned about energy in 1985. Generally, energy (including oil) was plentiful and available at higher but affordable prices. An improving energy environment and decreased demand were indicated by the fact that oil imports from all sources decreased from almost 50 percent of our needs in 1979 to 28 percent in 1983. The United States had also reduced its dependence on Persian Gulf oil dramatically, although U.S. allies were still highly dependent on Middle East oil. U.S. dependence on imports from the Arab members of the Organization of Oil Exporting Countries (OPEC) decreased from 17 percent in 1977 to 4 percent in 1983. During that same period imports increased from countries such as Mexico, Canada, Venezuela, Indonesia, and the United Kingdom. By early 1935 the Strategic Petroleum Reserve (SPR) had reached a 3-month-supply level at then current consumption rates. The SPR inventory was almost two-thirds of the goal of 750 million barrels set in the mid-1970s. The Reagan Administration leaned toward buying less oil for the SPR as it sought means of reducing the Federal deficit in the early months of the President's second term.

While these data on reduced imports and reduced consumption in the early 1980s are encouraging, the efforts to develop new energy sources and to find alternatives to oil have not been particularly successful. The critical importance of energy to our economic well-being; our continued reliance on imports; and our questionable ability to be self-sufficient, if that became necessary, are good reasons for national security managers to familiarize themselves with the status of our energy industries and the issues relating to energy.[1]

The world's largest industrial economy, the United States, uses 25 to 30 percent of the total world consumption of energy. The production and flow of energy are shown in figure 6. In 1984 total U.S. energy consumption was 73.5 quadrillion British thermal units (Btus). A British thermal unit is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at or near 39.1 degrees Fahrenheit. A quadrillion Btus are often referred to as a quad. It may be useful to note that one quad is approximately equal to each of the following:

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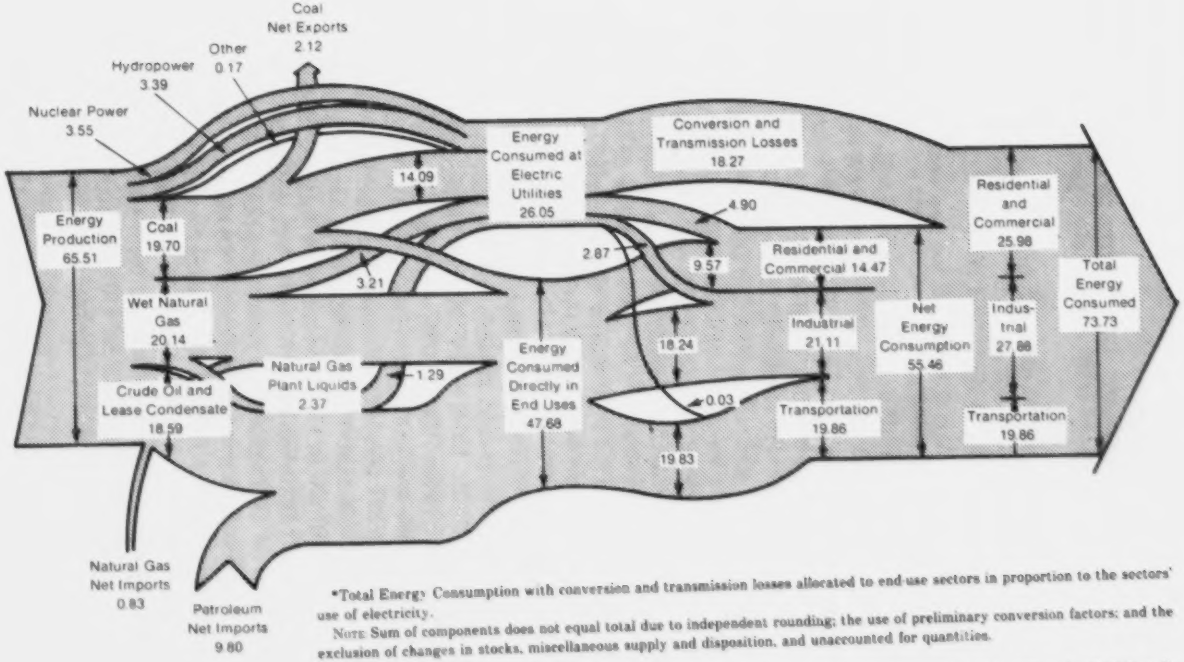
[1] Much of the data in this chapter are from publications of the U.S. Department of Energy's Information Administration, including *Annual Energy Review 1984*, April 1985; *Petroleum Supply Annual 1983*, 2 volumes, June 1984; *Natural Gas Annual 1983*, March 1985; *Coal Data: A Reference*, January 1985; *Electric Power Annual 1983*, July 1984; and other publications.

—974 billion cubic feet of natural gas (dry).
—172 million barrels of crude oil.
—45.9 million short tons of coal.
—500,000 barrels per day of crude oil for one year.
—8.0 billion gallons of gasoline.

The shares in percent contributed by energy sources to total consumption in 1984 were: oil 42; gas 24; coal 23; nuclear 5; hydro/geothermal 5; and other 1. Actual and projected data on U.S. energy production and conversion at table 8 indicate the expected trends in production, imports, and conversion to electricity through the year 2000. The most obvious conclusions are: coal production and use are expected to increase, with coal making an even larger contribution to the production of electricity; domestic oil production will continue to decline; and natural gas production will decline slightly. Oil imports will tend to level off in the 1985 to 1990 timeframe. The United States produces most of the energy it uses. In 1984 it produced approximately 83 percent of total consumption. Oil has been by far the largest import of energy since the early 1970s, and oil imports are expected to furnish 10 to 15 percent of total energy requirements through the year 2000.

Energy consumption increased steadily as the U.S. economy expanded from the 1950s until 1974. Since 1973 the pattern of consumption has been irregular. From 1958 to 1973, when energy was generally plentiful and prices were low, energy consumption in the United States grew at an annual rate of 4 percent, with the total reaching 74.6 quads in 1973. With the development of the energy crisis, caused largely by the cutoff of oil from OPEC in 1973, consumption declined slightly in 1974, 1975, and 1976. It again increased from 1977 through 1979, rising in 1977 and 1978 at an average annual rate of approximately 2.4 percent and in 1979 by almost 1 percent, reaching 78.9 quads in 1979. The latter year marked not only a peak in total energy consumption in recent years but also in imports of oil as a percentage of total oil consumption. The trend in energy consumption from 1980 to 1983 was downward. The annual rate of decline for 1979 through 1982 was 3.5 percent, and from 1982 to 1983 it was .5 percent. In 1984 consumption again increased slightly.

Although recessions always bring consumption down, the lower levels of consumption in the years indicated above can be attributed largely


Coal
Net Exports
2.12
Other
0.17
Hydropower
3.39
Nuclear Power
3.55
Energy
Production
65.51
Coal
19.70
Wet Natural
Gas
20.14
Crude Oil and
Lease Condensate
18.59
Natural Gas
Plant Liquids
2.37
1.29
14.09
3.21
Energy
Consumed at
Electric
Utilities
26.05
Energy
Consumed
Directly in
End Uses
47.68
Conversion and
Transmission Losses
18.27
4.90
2.87
9.57
18.24
0.03
19.83
Residential and
Commercial 14.47
Industrial
21.11
Transportation
19.86
Net
Energy
Consumption
55.46
Residential
and
Commercial
25.98
Indus-
trial
27.88
Transportation
19.86
Total
Energy
Consumed
73.73
Natural Gas
Net Imports
0.83
Petroleum
Net Imports
9.80

*Total Energy Consumption with conversion and transmission losses allocated to end-use sectors in proportion to the sectors' use of electricity.

NOTE: Sum of components does not equal total due to independent rounding; the use of preliminary conversion factors; and the exclusion of changes in stocks, miscellaneous supply and disposition, and unaccounted for quantities.

SOURCE: U.S. Department of Energy, *Annual Energy Review 1984* (Washington: Government Printing Office, April 1985), p. 3.

FIGURE 6. TOTAL ENERGY FLOW DIAGRAM, 1984
(quadrillion Btus)

TABLE 8: U.S. ENERGY PRODUCTION, IMPORTS, AND CONVERSION
(quadrillion Btus per year)

	Actual		Projected	
	1980	1985	1990	2000
Domestic production				
Oil	20.5	19.3	17.8	16.0
Shale oil	-	-	0.2	1.1
Natural gas	20.1	18.7	18.4	17.5
Coal	19.2	21.7	25.8	37.0
Nuclear	2.7	4.9	7.3	9.2
Hydro/geothermal	3.0	3.2	3.4	4.1
Renewables	1.8	2.2	2.7	5.0
Subtotal	67.3	70.0	75.6	90.0
Net imports				
Oil	13.4	12.3	12.7	9.8
Gas	1.0	1.2	1.8	2.2
Electricity	0.1	0.1	0.1	0.1
Coal (exports)	(2.4)	(3.0)	(3.2)	(5.1)
Subtotal	12.2	10.6	11.5	7.0
Total consumption	77.7	80.6	87.0	97.0
Net oil imports (MMBD)	(6.3)	(5.8)	(6.0)	(4.6)
Energy conversion				
Electricity inputs				
Oil	2.6	2.3	1.8	1.0
Gas	3.8	2.9	2.9	2.0
Coal	12.1	14.6	17.6	23.5
Nuclear	2.7	4.9	7.3	9.2
Other	3.0	3.2	3.5	5.4
Subtotal	24.1	28.0	33.1	41.4
Coal for synthetics	-	-	0.5	2.3

NOTES:
Energy projections developed in preparation of the fourth National Energy Policy Plan (NEPP-IV).
Excludes Strategic Petroleum Reserve and U.S. territories net imports.
Totals may not add due to rounding. Excludes 1.8 quad stock increase in 1980.

SOURCE: Adapted from U.S. Department of Energy, *Notice of Public Hearing on National Energy Policy Plan*, Table 2, 1983.

to increased fuel costs, particularly the cost of oil. Oil prices rose from $2.41 per barrel in January 1973 to $34 per barrel in January 1982. Price hikes in 1973 to 1974 and 1979 to 1980 were significant. The effect of OPEC price increases was felt particularly in the late 1970s because in 1979, when almost half of U.S. oil consumption was imports, more than three-fourths of oil imports were from OPEC. Natural gas prices, too, have jumped because supplies tended to remain on a plateau and "new gas" at much higher prices has been replacing "cheap gas," pre-1977 gas under long-term contracts. Coal prices also rose following the 1973-1974 oil embargo by OPEC but less dramatically than those of oil and gas. The development of a world "oil glut" in 1982, which has continued through early 1985, caused energy prices to moderate.

Noteworthy progress has been made in cutting energy consumption and in decreasing the degree of dependence on imports, particularly oil in the period 1980 to 1983. Energy consumption per capita decreased by 14 percent from 1973 to 1983. In 1978 the gap between consumption and production was 47 trillion Btus per day; by 1983 it had narrowed to 23 Btus per day. After consumption peaked at 78.8 quads in 1979, in successive following years, energy use declined to 70 to 71 quads in 1982 and 1983. Conservation, improved efficiency in the use of energy, and shifts to different types of energy have contributed to reduced consumption. Increased energy costs as calculated in 1972 constant dollars were as indicated in the following data. The consumer was paying 60 cents per gallon for leaded gasoline in 1981 as compared to 45 cents in 1974. The cost of natural gas per thousand cubic feet for homeowners rose from $1.21 in 1973 to $2.55 in 1983. Residential customers were paying 3 cents per kilowatt hour in 1983 as compared to 2.4 cents in 1973. These comparisons, if depicted in current dollars for the years indicated would, of course, show much greater differentials because of the inflation factor. For example, the cost of natural gas to homeowners would be $1.29 in 1973 as compared to approximately $6 per thousand cubic feet at current prices in 1983.

Industrial efficiency improved following the 1973-1974 oil embargo resulting in energy economies. Energy input per unit of industrial output declined 14 percent per unit of industrial input between 1973 and 1983. U.S. use of gasoline fell 15 percent from 1978 to 1983 largely because of more fuel-efficient and smaller cars. Average annual passenger car mileage per gallon of fuel consumption increased from 13.1 in 1973 to an estimated 16.3 in 1982. American utilities reduced their use of oil between 1978 and 1982 by 61 percent mostly by burning more coal and smaller shares of oil and gas. Improvements in efficiencies for all sorts of applications are expected to continue. The U.S. Energy Information Administration estimates that between 1983 and 1995 the quantity of energy consumed in the United States will increase by 1.7 percent per year while the GNP is projected to increase by 2.9 percent per year.

U.S. energy production has not kept up with consumption, particularly since the 1960s, but the most serious difficulty has resulted from the shortfall in oil and dependency on oil imports from OPEC in the 1970s. (See *table 9* for data on supply and disposition for selected years.) Oil production peaked at 20.4 quads in 1970. Since that time it has decreased slightly remaining generally on a plateau in the range of 17.3 to 18.6 quads in the period 1974 to 1983. Natural gas output peaked in 1971 at 22.28 quads, and since that time it has declined. Coal, the third major fuel, has become a larger contributor rising from 14.5 quads in 1970 to 18.6 quads in 1982. By far the largest increase in the use of coal has been generation of electricity.

Although the energy crisis of the 1970s has passed, its impact continues to have influence and reminds us of the vulnerabilities that stem from dependence on energy imports. Let us briefly summarize the causes and effects of that crisis, which were significant not only for the United States but also for both the developed and developing nations. The oil embargo by OPEC in 1973 to 1974 to punish the United States for its support of Israel in the Arab-Israeli War revealed the vulnerability of the industrialized countries with utmost clarity. The embargo served as a catalyst for forces that were taking shape over several years. The shift in world energy to petroleum from coal after 1950 and the sharp increase in world consumption of energy just before the 1973-1974 oil embargo were basic factors in the world energy environment of the 1970s. The share of oil and gas in world energy consumption was 64 percent in 1972 as compared to 38 percent in 1950; over the same period coal experienced a relative decline from 56 to 29 percent. Changes in the American pattern of fuel consumption in this period were somewhat different from the world pattern, but in the end they aggravated the problem of petroleum supplies. The proportion of oil in U.S. energy consumption rose rather modestly between 1950 and 1970, with the rapid rise in energy demand being filled by natural gas. U.S. oil production was not able to keep up with demand, and between 1962 and 1973 oil imports as a share of consumption grew from 20.7 to 29.7 percent. Although U.S. oil consumption slackened in 1974 and 1975, it rose again in the period 1976 to 1979 causing imports to rise substantially. OPEC raised prices in 1974 and again when U.S. oil imports were peaking in 1979. Increased oil prices were a major factor in the rapid rise in the rate of inflation from the mid-1970s through 1981. In the 1970s oil consumption increased at a disproportionately fast rate because natural gas supplies leveled off; in fact, they declined from 1971 peak production. Coal utilization met tight environmental constraints, and demand for oil in the transport sector continued at high levels. From 1973 to 1977 U.S. dependence on OPEC imports rose from 17 percent to 34 percent of total oil consumption.

The United States is still the world's largest importer of oil, despite the substantial reductions in the early 1980s in imports, particularly from the Arab OPEC countries. The volatile Middle East remains vitally important to the United States even though only about 3 percent of our oil requirements come from the Persian Gulf. We are part of an international market and our allies are still heavily dependent on Persian

TABLE 9. ENERGY SUPPLY AND DISPOSITION, 1960, 1970, AND 1973-1984
(quadrillion Btus)

Activity and energy source	1960	1970	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984[1]
Supply														
Production														
Crude oil and lease condensate	14.93	20.40	19.49	18.57	17.73	17.26	17.45	18.43	18.10	18.25	18.15	18.31	18.39	18.59
Natural gas plant liquids	1.46	2.51	2.57	2.47	2.37	2.33	2.33	2.25	2.29	2.25	2.31	2.19	2.18	2.37
Natural gas[2]	12.66	21.67	22.19	21.21	19.64	19.48	19.57	19.49	20.08	19.91	19.70	18.25	16.53	17.75
Coal	10.83	14.61	14.00	14.08	15.00	15.66	15.76	14.91	17.55	18.60	18.38	18.64	17.25	19.70
Nuclear power	0.01	0.24	0.91	1.27	1.90	2.11	2.70	3.02	2.78	2.74	3.01	3.13	3.20	3.55
Hydroelectric power	1.61	2.63	2.86	3.18	3.15	2.98	2.33	2.94	2.93	2.90	2.76	3.26	3.50	3.39
Other[3]	(11)	0.02	0.05	0.06	0.07	0.08	0.08	0.07	0.09	0.11	0.13	0.11	0.13	0.17
Total production	41.50	62.08	62.07	60.84	59.87	59.90	60.22	61.11	63.81	64.76	64.42	63.89	61.20	65.51
Imports														
Crude oil[4]	2.20	2.81	6.89	7.40	8.72	11.24	14.03	13.46	13.83	11.19	9.34	7.42	7.08	7.25
Petroleum products[5]	1.80	4.66	6.58	5.73	4.23	4.43	4.73	4.36	4.11	3.46	3.30	3.36	3.57	4.10
Natural gas	0.16	0.85	1.06	0.99	0.98	0.99	1.04	0.99	1.30	1.01	0.92	0.95	0.94	0.88
Other[6]	0.07	0.07	0.20	0.30	0.19	0.18	0.30	0.44	0.38	0.31	0.42	0.36	0.44	0.48
Total imports	4.23	8.39	14.73	14.41	14.11	16.84	20.09	19.25	19.62	15.97	13.97	12.09	12.03	12.71
Adjustments[7]	-0.43	-1.37	-0.46	-0.48	-1.07	-0.18	-1.95	-0.34	-1.66	-1.05	-0.08	-0.51	1.00	-0.68
Total supply	45.30	69.10	76.34	74.77	72.91	76.55	78.36	80.02	81.77	79.68	78.32	75.47	74.22	77.54

TABLE 9. ENERGY SUPPLY AND DISPOSITION, 1960, 1970, AND 1973-1984 (cont.)
(quadrillion Btus)

Activity and energy source	1960	1970	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984[1]
Disposition														
Exports														
Coal	1.02	1.94	1.43	1.62	1.76	1.60	1.44	1.08	1.75	2.42	2.94	2.79	2.04	2.15
Crude oil and petroleum products	0.43	0.55	0.49	0.46	0.44	0.47	0.51	0.77	1.00	1.16	1.26	1.73	1.57	1.55
Other[8]	0.03	0.18	0.14	0.14	0.16	0.12	0.12	0.09	0.11	0.14	0.12	0.11	0.11	0.12
Total exports	1.48	2.66	2.05	2.22	2.36	2.19	2.07	1.93	2.87	3.72	4.33	4.63	3.72	3.82
Consumption														
Petroleum products[9]	19.92	29.52	34.84	33.45	32.73	35.17	37.12	37.97	37.12	34.20	31.93	30.23	30.05	31.00
Natural gas	12.39	21.79	22.51	21.73	19.95	20.35	19.93	20.00	20.67	20.39	19.93	18.51	17.36	18.03
Coal	9.85	12.27	12.98	12.67	12.67	13.59	13.92	13.77	15.04	15.43	15.91	15.32	15.90	17.20
Nuclear power	0.01	0.24	0.91	1.27	1.90	2.11	2.70	3.02	2.78	2.74	3.01	3.13	3.20	3.55
Hydroelectric power[10]	1.66	2.65	3.01	3.31	3.22	3.07	2.51	3.14	3.14	3.12	3.11	3.56	3.87	3.78
Other[3]	([11])	0.02	0.05	0.06	0.07	0.08	0.08	0.07	0.09	0.11	0.13	0.11	0.13	0.17
Net imports of coal coke	-0.01	-0.06	-0.01	0.06	0.01	([11])	0.01	0.12	0.06	-0.04	-0.02	-0.02	-0.02	-0.01
Total consumption	43.81	66.44	74.29	72.55	70.55	74.37	76.29	78.09	78.90	75.96	73.99	70.84	70.50	73.73
Total disposition	45.30	69.10	76.34	74.77	72.91	76.55	78.36	80.02	81.77	79.68	78.32	75.47	74.22	77.54

[1] Preliminary.

[2] Dry natural gas.

[3] Includes electricity produced from geothermal, wood, waste, wind, photovoltaic, and solar thermal sources connected to electric utility distribution systems (see Note).

[4] Includes imports of crude oil for the Strategic Petroleum Reserve, which began in 1977.

[5] Include imports of unfinished oils and natural gas plant liquids.

[6] Includes coal, coal coke, and hydroelectric power.

[7] A balancing item. Includes stock changes, losses, gains, miscellaneous blending components, unaccounted for supply, and anthracite shipped overseas to U.S. Armed Forces.

[8] Includes natural gas, coal coke, and hydroelectric power.

[9] Petroleum products supplied includes natural gas plant liquids and crude oil burned as fuel.

[10] Includes industrial generation of hydroelectric power and net electricity imports.

[11] Less than 0.005 quadrillion Btus.

NOTE: Data do not include the consumption of wood energy (other than that consumed by the electric utility industry) which amounted to an estimated 2.6 quadrillion Btus in 1983. This table also does not include small quantities of other energy forms for which consistent historical data are not available, such as geothermal, waste, wind, photovoltaic, or solar thermal energy sources except that consumed by electric utilities.

NOTE: Sum of components may not equal total due to independent rounding.

SOURCE: U.S. Department of Energy, *Annual Energy Review 1984* (Washington: Government Printing Office, April 1985), p. 5.

sian Gulf oil. Western European countries receive 20 to 40 percent of their oil supplies from the Persian Gulf, and Japan receives about 60 percent.

Many of the Nation's oil companies were of the opinion in mid-1985 that declining petroleum refining capability was leading to a dangerously vulnerable position. A severe squeeze on profit margins and the ending of Government-mandated subsidies led to the closing of more than 100 refineries since 1981 and reduced operable capacity from 18.6 million to 15.6 million barrels a day. The oil companies pointed out that OPEC can undersell even the most efficient American refinery. On the other hand, utilization of American refineries was only 76.7 percent in April 1985 and the campaign for import restrictions appeared unlikely to succeed.[2]

SOURCES OF ENERGY

Petroleum

Petroleum and natural gas have been key fuels in recent decades, but their production and consumption have tended to level off. Petroleum, a combustible liquid hydrocarbon, is formed in the upper strata of the earth usually at depths shallower than 1,000 feet. Known oil deposits are distributed unevenly and a disproportionately large share, about 55 percent, is located in the Middle East, with 25 percent in Saudi Arabia alone. U.S. recoverable reserves are estimated to be about 28 billion barrels, approximately 4 percent of the world total and less than 10 percent of total U.S. estimated energy reserves.

In the early 1970s the United States was the world's leading producer of oil. Production peaked in 1970 at 20.4 quads or 11.3 million barrels per day, and since that time annual production has ranged from 17.2 quads to 20 quads, with 1983 output at 18.3 quads. In 1983 United States crude oil production was 8.68 million barrels per day as compared to 11.82 million barrels per day for the Soviet Union, the world's largest producer. Consumption was 15.2 million barrels per day; thus, there was the requirement for imports of crude oil and petroleum products that averaged 4.3 million barrels per day in 1983. Petroleum prices fell in 1983, for the second straight year, reflecting continued plentiful supplies of oil on the world market. The cost of imported crude oil to the refiner decreased from $33.55 in 1982 to $29.30 per barrel in 1983. Crude oil inputs to refineries averaged 11.7 million barrels per day. Refineries operated at 78 percent of capacity in September 1983—the highest level of utilization since February 1980.

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[2] Robert D. Hershey, Jr., "Economic Scene," *The New York Times*, May 10, 1985, p. D2.

Drilling for oil and natural gas picked up in tempo following the 1973-1974 oil embargo and then surged upward in 1980 and peaked in 1981 with 3,974 oil drilling rigs in operation in 1981. There was a downward trend in drilling in 1982 as the world oil supply improved. The average number of rigs operating in December 1983 was 2,780 as compared to 2,696 a year earlier. In the peak year of 1981 more than 80,000 wells were drilled. The downturn in drilling brought increased competition to the drilling contractor and service segments of the oil industry.

Natural Gas

Natural gas is essentially methane, which is often found and produced in conjunction with crude petroleum. It is one of the most convenient and useful forms of energy. Moreover, because natural gas has been cheaper than oil and is a relatively clean burning fuel, it is in high demand in urban and other areas where air pollution is of major concern.

From 1950 to the early 1970s, demand for gas increased at nearly twice the rate of total energy demand. The inordinate growth rate for this energy source resulted from its availability, its many uses as a desirable fuel, and the favorable price to consumers. Use of gas in households, in commercial activities, and in generation of electricity expanded especially rapidly in this period. The relatively high demand for gaseous fuel is likely to continue because of its efficiency and its low sulphur discharge, a characteristic needed to minimize air pollution. Because of limited supplies, consumption of natural gas leveled off in the 1970s and then declined slightly after reaching a peak in 1972 at 22.7 trillion cubic feet. It remained at approximately 20 trillion cubic feet until 1981 and then declined further. Production of gas declined in 1982 after remaining steady for almost a decade. In 1983 production dropped more sharply to 16.8 trillion cubic feet, the lowest annual production since 1965. Despite these declines the United States is the largest producer of natural gas—in 1981 producing 35.6 percent of the world total.

Some 90 percent of U.S. natural gas needs is supplied from domestic sources. In 1983 Texas accounted for 35 percent of marketed production, Louisiana for 32 percent, and Oklahoma for 10 percent. Offshore areas produced 25 percent of total withdrawals, with Louisiana furnishing 77 percent and Texas nearly 21 percent of the offshore total. Overall about three-fourths of natural gas withdrawals were from gas wells and about one-fourth was produced along with crude oil from oil wells. Imports ranged from .9 to 1 trillion cubic feet annually from 1971 to 1983, contributing roughly 5 percent to total consumption annually. In the 1980s imports were largely from Canada. Plans for liquid natural gas (LNG) imports from the Soviet Union in the mid-1970s did not materialize, and imports from Algeria have been on a small scale, partly because of high prices.

Despite reports in recent years that there has been an oversupply of gas on the U.S. market, the fundamental fact is that natural gas supplies have been limited since the late 1960s when shortages began to appear. Total proved natural gas reserves were 200.2 trillion cubic feet in 1984. In the past decade production of gas has exceeded the addition of new reserves. U.S. total proved reserves reached their alltime peak in 1970 at 290.7 trillion cubic feet. At recent rates of consumption U.S. reserves will provide less than a 10-year supply. Since natural gas is a desirable fuel and has been cheaper than oil as a fuel, consumption would have continued to grow if normal demand factors had been allowed to operate. Distribution companies have had to curtail orders. For example, during the 1975-1976 heating season, curtailments of firm delivery commitments amounted to almost 1.3 trillion cubic feet. Also, service to prospective new customers has been denied in some cases. For example, in the 1970s in some areas gas heating could not be installed in large multiunit housing complexes. The Soviet Union, which has more than 40 percent of world reserves, more than five times larger than those of the United States, produced 30.1 percent of the world total and in recent years has been expanding its output rapidly.

The flow of gas in the United States is shown in figure 7. Shares of deliveries to customers, as indicated in the data were: industrial, 42 percent; residential, 25 percent; electric utilities, 18 percent; and commercial, 14 percent. The gas industry and pipelines used about 10 percent of gross withdrawals.

Underground storage of natural gas, to meet fluctuating seasonal and daily requirements, has expanded in the period since the oil embargo of 1973 to 1974. At the beginning of the 1983-1984 heating season (October 1983), the total volume of gas in underground storage was 7.1 trillion cubic feet. This total was approximately 25 percent above the level of the previous decade.

Natural gas prices have risen since 1974 and at a faster rate in the 1980s. There are many gas price categories resulting from different rate structures. The price for "old gas," gas contracted for before 1977, and for "new gas," gas purchased in 1977 and after, is quite different; most of the long-term contracts made in the 1960s and until 1974 were in the range of 19 to 23 cents per thousand cubic feet at the wellhead while the price, again in 1972 dollars, of "new gas" has been from 56 cents to $1.21. Estimated average wellhead prices in 1984 varied from $1.45 per thousand cubic feet for "old gas" to $5.38 per thousand cubic feet for "high-cost gas" at then current prices. In 1983, residential consumers paid an average of $6.06 per thousand cubic feet, an increase of 17 percent from the 1982 average.

In summary, it appears that natural gas supplies and prices probably will not improve, even though imports, mostly from Canada, may increase somewhat.[3]

Coal

Coal played an important role in the development of the Nation. It continues to be a major source of energy, but its contribution as a share of total energy has declined since World War II. In 1983 coal provided 22 percent of the national energy supply as compared to 52.4 percent in 1940. There has been renewed interest in coal and in substituting it for oil and natural gas since coal accounts for more than three-fourths of the total fossil fuel energy base.[4]

Coal production in 1984 reached a record high of 890 million tons of which more than 70 percent was bituminous. (See *figure 8* for additional major data on coal.) Coal production is valued at more than $20 billion, and coal exports are valued at more than $4 billion, adding favorably to the U.S. international balance of payments. During the 1970s annual coal production fluctuated from 561 million tons to 781 million tons. Production is expected to reach 1,045 million tons by 1990. While coal was mined in 26 States, approximately three-fourths was produced by eight: Kentucky, West Virginia, Wyoming, Pennsylvania, Illinois, Texas, Virginia, and Ohio. In 1984 some 34 percent of coal was produced west of the Mississippi River.

Productivity, measured in tons of coal per miner per day, reached a record high in 1969 and then declined until 1978; the decline was largely because of environmental and safety regulations and the rush to expand production. The trend since 1978 has been toward increased productivity. In 1982 productivity in bituminous and lignite mines averaged 11.2 tons for underground mining and 30.6 tons for surface mines. For anthracite it was 4.5 tons.

More than 80 percent of coal consumed in recent years has been used for generating electricity. Each ton of coal fed into an electric powerplant generates about 2,000 kilowatt-hours of electricity. About 56 percent of electric generation in 1984 was from coal. Between 1979 and 1983 generation from coal increased at an annual average rate of 4 percent. This increase was because coal was the cheapest of the fossil fuels and a domestic supply was readily available. The economy of using coal for electric power is illustrated in data for 1983. The average costs of fossil fuels at steam electric utility plants of 50 megawatt or larger

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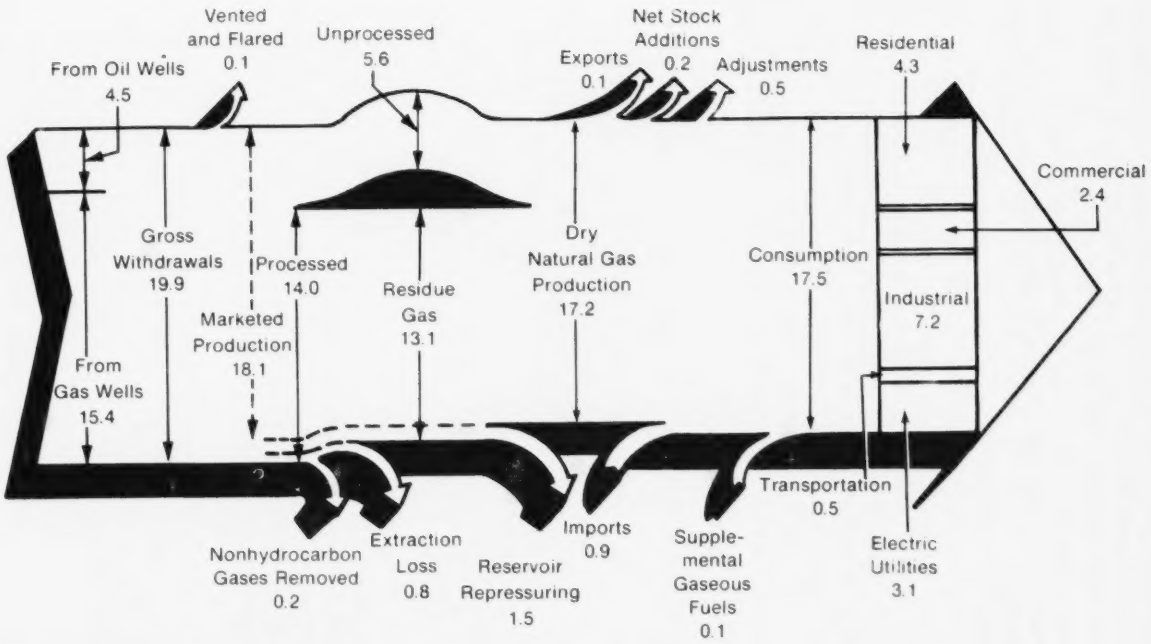
[3] U.S. Department of Energy, *Annual Energy Review 1984* (Washington: Government Printing Office, April 1985), p. 129.

[4] Data in this section are mostly from *Annual Energy Review 1984* and *Annual Energy Review 1983*.


From Oil Wells 4.5
Vented and Flared 0.1
Unprocessed 5.6
Exports 0.1
Net Stock Additions 0.2
Adjustments 0.5
Residential 4.3
Commercial 2.4
Gross Withdrawals 19.9
Processed 14.0
Marketed Production 18.1
Residue Gas 13.1
Dry Natural Gas Production 17.2
Consumption 17.5
Industrial 7.2
From Gas Wells 15.4
Nonhydrocarbon Gases Removed 0.2
Extraction Loss 0.8
Reservoir Repressuring 1.5
Imports 0.9
Supple-mental Gaseous Fuels 0.1
Transportation 0.5
Electric Utilities 3.1

NOTE Sum of components may not equal totals due to independent rounding.

SOURCE U.S. Department of Energy, *Annual Energy Review 1984* (Washington: Government Printing Office, April 1985), p. 131.

FIGURE 7. NATURAL GAS FLOW DIAGRAM, 1984
(trillion cubic feet)

capacity per million Btus were: coal, $1.66; natural gas, $3.47; and, petroleum, $4.63. Coal and nuclear power are the primary options for meeting future demands for new generating capacity.

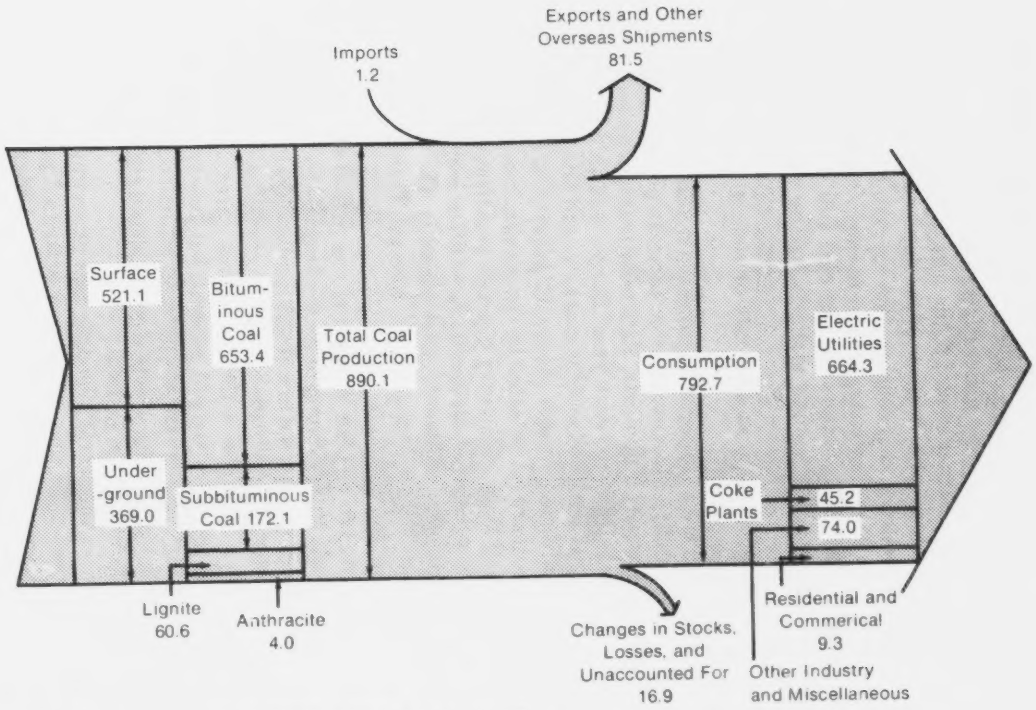
The second largest consumer of coal is the iron and steel industry, which uses coal to produce coke. Because of the depressed state of the U.S. iron and steel industry, coal consumption by coke producers has fallen from more than 90 million tons per year in the 1970s to less than 40 million tons in 1983. Conventional use of coal will continue, and research is underway to develop new methods, among which are coal gasification and coal liquefication. Some developments combine coal with other substances, and others eliminate or reduce the ill effects of burning some types of coal.

Transportation costs are an important element in the competitiveness of coal, and the availability of transportation to ocean ports is critical to expansion of coal export shipments. Railroads transport about 60 percent of the total coal shipped each year. Barges and ships deliver some 16 percent of coal sent to domestic markets, and trucks, important in short-haul deliveries, handle almost 14 percent of deliveries. Smaller amounts of coal are transported by conveyors, tramways, and the 273 mile-long Black Mesa coal slurry pipeline in Arizona, the only coal slurry pipeline in operation. Railroads have effectively opposed further slurry pipeline development, most recently the line from Wyoming to the Gulf Coast proposed by Energy Transportation Systems Incorporated and affiliates.

Transportation costs are a major element of the cost of coal to the consumer. The railroads have a strong influence because an estimated 85 percent of coal mines are captive to a single local-area railroad, and, therefore, must pay what the railroads charge. Increased rail transportation costs have been a big factor in the rise of coal prices. From 1977 to 1981 the cost of coal increased only 31 percent, but average railroad charges for transporting coal increased 66 percent. Bituminous coal and lignite costs, at current prices, for electric powerplants rose from $9 per ton in 1973 to $35.50 per ton in 1983.

The United States, as the world's leading coal exporting country, sometimes has exported more than 10 percent of annual production. In the 1970s coal exports to foreign countries ranged from 40 to 72 million tons per year. They increased to a 1981 peak of 112.5 million tons; then they declined to 106.3 million tons in 1982 and to 77.8 million tons in 1983. Estimates were that exports increased to 82.6 million tons in 1984.

The U.S. reserve base of coal is estimated at 483 billion tons, and total coal resources are estimated at more than 3.9 trillion tons, enough to last more than a hundred years at the current rate of use. The coal reserve represents 85 percent of the total U.S. reserve energy base.


Imports
1.2
Exports and Other
Overseas Shipments
81.5
Surface
521.1
Under
-ground
369.0
Bitum-
inous
Coal
653.4
Subbituminous
Coal 172.1
Lignite
60.6
Anthracite
4.0
Total Coal
Production
890.1
Consumption
792.7
Changes in Stocks,
Losses, and
Unaccounted For
16.9
Electric
Utilities
664.3
Coke
Plants
45.2
74.0
Residential and
Commerical
9.3
Other Industry
and Miscellaneous

NOTE Sum of components may not equal totals due to independent rounding.

SOURCE U.S. Department of Energy, *Annual Energy Review 1984* (Washington: Government Printing Office, April 1985), p. 147.

FIGURE 8. COAL FLOW DIAGRAM, 1984
(million short tons)

Coal-bearing rocks underlie almost 13 percent of the U.S. land area. Coal is mined from 370 beds, but more than half comes from 20 beds. The leading bed is Wyodak in Wyoming, a subbituminous layer that averages 67 feet in thickness. The Pittsburgh bed, a 5-foot layer of bituminous coal in Pennsylvania, Ohio, West Virginia, and Maryland, now ranks second; for many years it was the most important U.S. coalbed. The Mississippi River divides the demonstrated reserve base of 483 billion tons nearly in half.

Air pollution from coal is the major obstacle to the substitution of coal for other fuels. Sulphur dioxide emissions and acid rain are the main problems from the burning of coal. Even though sulphur dioxide emissions have decreased 15 to 20 percent over the past 20 years, air pollution remains a serious problem. Acid rain in 1985 was a matter of great public concern and was adversely affecting U.S.-Canadian relations. Efforts are being directed principally at technologies to permit coal to be burned with minimal environmental impact, such as flue-gas cleanup, gas-stream cleanup, and coal preparation.

Coal-Based Synthetic Fuels

Synthetic fuels generally are liquid fuels such as gasoline, jet fuels, and fuel oils as well as readily combustible gases derived from sources other than crude oil and natural gas. Synthetic fuels, or synfuels, as they are commonly termed, come mostly from coal. In 1980, the United States Synthetic Fuels Corporation was established by the Energy Security Act to accelerate the development of the synthetic fuels industry.[5] When the Synfuel Corporation was created, it was expected the energy crunch would be permanent, and the search was on to find alternative fuel sources. Originally, it was proposed that 500,000 barrels per day of crude oil equivalent would be produced by 1987. By 1992, the goal was to produce 2 million barrels daily. Synthetic fuels officials have since pared down their forecasts to a handful of synthetic fuel plants, and in early 1985 the Synfuel Corporation was barely able to survive.

The concept of synthetic fuels has existed for a long time. Gas produced from coal was used in 1813 to light the London Bridge. Before natural gas was available, a process used to produce synthetic gas, consisting of hydrogen and carbon monoxide and called "town gas," was used to light American cities. When petroleum was cut off to the Germans in World War II, fuel from liquid coal was used by the German Air Force.

The processes most commonly considered for synfuels are coal gasification and coal liquefaction. Biomass is another type of synfuel, which includes wood, grain, and industrial waste and is an important renewable energy resource. Contributions to the energy system for biomass are limited because the supply of biomass is limited and because the Synthetic Fuels Corporation specifically excludes biomass-derived fuels from its definition of synthetic fuels; therefore, biomass is excluded from synfuel financial support. This section will focus on the potential contributions of oil shale and the coal gasification and coal liquefaction processes.

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[5] 94 Stat. 636; 42 U.S.C. 8711.

The technology behind gasifying coal is not new. Some forms of synthetic gas (SNG) with a low Btu rating have been used in firing brick kilns for nearly 40 years. In coal gasification, coal is usually crushed or dried and then fed into a gasifier or reactor under high pressure and reacted with steam, air, or oxygen, or all three. The reaction is a methane gas and some dirty elements, primarily carbon monoxide. After sulfur is taken out, a fairly good synthetic gas results except that it has a lower heat value than natural gas. The synthetic gas can be upgraded to a pipeline quality of 1,000 Btu through further processing, but it is normally used in a medium Btu range of 200 to 900 and a low Btu range of below 200.

In the coal gasification process there are environmental problems and at the same time the possibility of large-scale production. The process is undertaken in high pressures of 1,000 pounds per square inch (PSI) gauge and high temperatures in excess of 2,000°F. There are erosive problems with the sulfur and chlorine compounds in gasification. The potential for large-scale production stems from the fact that an estimated 225 billion tons of coal deposits are available in the United States that potentially could be converted into 500 billion barrels of oil.

It takes increased oil prices that are good for OPEC and bad for the United States to make synthetic fuels attractive economically. The Great Plains Coal Consortium is seeking price supports from the Government Synthetic Fuels Corporation. The owners contend that a pricing formula tied to the price of heating oil, which has been rising slower than originally anticipated, could cause losses possibly in excess of $770 million in the first 10 years of operation instead of earnings of over $1 billion.

The other coal-based synthetic fuel process is coal liquefaction, which basically builds on the gasification process. In its simplest form, coal liquefaction converts methane gas to methanol and then to synthetic gasoline. Liquefaction normally implies liquid products, but several conversion processes produce gaseous and solid products. By varying the operating conditions of different processes, a wide range of liquid products can be produced: heavy fuels for electric utilities, distillate fuel oil, and gasoline.

The conversion process of coal by the indirect liquefaction technology of gasification into gasoline and fuels has been in commercial operation in the South African Coal, Oil, and Gas Company (Sasol) in the Republic of South Africa since 1955. Unfortunately, synfuels produced under the Sasol process are considered the most expensive high-tonnage hydrocarbons in the world. The process would be considered economical only in areas where there is a large differential between the cost of indigenously produced coal and the price of imported oil.

A direct liquefaction process was commercially proven in Germany during World War II in support of the German war effort. Research continues to bring improvements in the direct liquefaction process. Although coal can be converted into fuels either by liquefaction or gasification, the liquefaction process has a less severe environmental impact. Coal liquefaction requires less chemical transformation and has an approximate 78 percent energy-conversion efficiency as compared to less than 70 percent for gasification. Further, since liquid fuels have a greater energy content than gaseous fuels, they are therefore cheaper to store and transport. In the United States, commercial direct liquefaction of coal is not expected before 1990. As mentioned earlier, lower energy prices and falling demand for oil are discouraging private investment in synthetic fuels.

Shale

Oil shale is the nearest geologic relative in chemical composition to petroleum in the United States and the cheapest alternative fuel having a large resource base. In both the Western and Eastern United States are located vast deposits of oil shale, which represent a domestic fossil energy resource only exceeded in magnitude by coal. After upgrading, crude shale oil is a premium feedstock for refineries because nearly the entire fluid can be converted to fuels such as gasoline and diesel oil. Estimates of oil from shale vary widely. Shale deposits of high quality may yield 42 gallons of oil per ton while the low grade deposits may produce only 10 to 20 gallons.

For several decades, there has been commercial interest in the vast U.S. oil shale resources. However, the limited quality and quantity of the resources available to the private sector plus the high costs of extracting, upgrading, and transporting oil shale to existing markets have precluded commercial development. At present, there are no commercial-size operations in this country, although there is activity at a number of sites in varying stages, ranging from preliminary design to small-scale retorting operations. Some U.S. companies had contemplated commercial operations, but in recent years have withdrawn as oil prices have declined.

Oil shale processing technology is subdivided broadly into two approaches: surface- and in-situ retorting. Surface retorting requires conventional mining, crushing the shale to a specific size, and heating it to about 900°F to convert the organic kerogen material it contains into a synthetic crude oil. This crude oil is upgraded by treating it with hydrogen to remove inpurities, particularly nitrogen, before it is used as a refinery feedstock. After retorting, about 80 to 85 percent of the oil shale remains as a solid waste that must be disposed of; this disposal represents a massive materials handling requirement as well as a potentially serious environmental control problem.[6]

In-situ technologies differ from surface processes in that they involve breaking up the shale underground in controlled patterns of particle size and permeability distribution and then heating the shale in place to produce oil. In-situ methods avoid the problems associated with surface disposal of spent shale, but potentially pose different environmental control problems that must be addressed. Some in-situ technologies are especially well suited to the particular geologic variations of oil shale deposits, but in general they are targeted for deposits that are less technically and/or economically attractive to conventional mining and surface processing.

Current and emerging technologies are economically appropriate for only a small percentage of the 1.8 trillion-barrel western oil shale resource, which is generally the richest layer near the top of shale deposits. Development of this zone by itself could destroy the potential for later development of the deeper deposits, the majority of which are federally owned.

The current goal of the Department of Energy is to concentrate on providing the data base required to develop the more efficient and environmentally benign second- and third-generation processes needed for increased economic recovery of western resources. No other Federa or State program duplicates the research and development missio related to long-term, high-risk technology-base development for second generation surface or in-situ extraction of shale oil. Private industr generally restricts research to relatively near-term developmental pro ects on specific processes; and, in fact, it has little incentive to pursu long-range generic research on oil shale.

Nuclear Energy

Nuclear-powered electric generating capacity provided nearly 16 p cent of the Nation's electricity at the beginning of 1985. Neither increased demand for electrical power nor a willingness to finance and license further expansion is pressing utility managers even though industry officials insist nuclear power has a future. The cost of electricity from nuclear powerplants is less than or competitive with electricity from coal-fired plants in most regions of the country and much less than that from oil-fired plants. Nuclear-powered facilities can displace increasingly expensive fossil fuels, allowing them to be available for other high-priority uses. Historically, however, the nuclear power industry has not realized its full production potential because of the unpredictability in regulatory requirements, public perceptions concerning the safety of the technology, and institutional and financial problems within the utility industry.

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[6] Much of the information on oil shale is taken from U.S. Department of Energy, Office of Policy, Planning Analysis, *Report to the Congress*, DOE Organization Act, Title X, Sunset Review, Vol. 2, February 1982, Washing pp. 59-64.

By February 1985 there were 88 nuclear reactors licensed for operation and four others in startup status. Two plants were on order and construction permits had been granted for 38, making a total of 132. Worldwide nuclear generation accounted for more than 10 percent of total electric production. The United States has the largest number of operable nuclear generating plants and the largest capacity, but some other nations are more heavily dependent on nuclear generation than the United States is. For example, in 1983 France got more than 48 percent of its electricity from nuclear reactors.[7] The United States accounts for more than 35 percent of nuclear electric generation in the noncommunist world.

In addition to helping to meet our future domestic power needs, a healthy nuclear industry is essential to our nonproliferation objectives. The United States will have sharply limited influence over other nations in the control of nuclear materials if we cease to maintain our professional and technical leadership in nuclear power. In July 1981, President Reagan declared that to realize our nonproliferation objectives, it is essential to reestablish the United States as a predictable and reliable partner for nuclear cooperation under adequate safeguards.

We also need to maintain our nuclear capability so we can compete in the international nuclear services and equipment market and negotiate agreements such as the one initiated in 1983 during President Reagan's trip to China and finalized during President Li's visit to the United States in July 1985. During the 1983 negotiations, China joined the International Atomic Energy Agency and clarified its nuclear export nonproliferation policies. These have been welcome steps. They might not have happened had we been unable to be a supplier of peaceful nuclear technology.

Despite its importance, the nuclear power industry in the United States has been plagued with powerplant cancellations, delays, and regulatory-related problems in recent years. Since 1972, more than 100 planned commercial nuclear plants have been cancelled. The primary problems facing the domestic nuclear power industry are the lengthening schedules for plant licensing and construction (currently from 12 to 14 years), the associated uncertainty in plant costs and difficulty in financing, and public opposition to further expansion of the nuclear generation program. The Three Mile Island accident in 1979 aroused considerable anxiety about the future of nuclear power and raised doubts about the human factor, the level of discipline required to provide essential safeguards in nuclear plants. More recently, cost overruns and financing have slowed progress. Cancellation of nuclear construction, in some cases after billions of dollars of investment, have resulted in large financial losses. The cost of the 100 nuclear plant cancellations from 1972 to 1982 was estimated at approximately $10 billion and more recent cancellations have resulted in further losses. For example, the Washington Public Power Supply System cancelled two nuclear reactors, then defaulted on bond payments of $2.5 billion, and this was only part of the total losses.[8]

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[7] *Monthly Energy Review*, February 1985, pp. 81-83 and U.S. Department of Energy, *Progress in Energy 1983-1984* (Washington: Energy Information Administration, September 1984), pp. 8-9.

By streamlining the regulatory and licensing process for new plant construction and by improving the economic climate for new capital investment, initiatives by the Reagan Administration are expected to make nuclear energy more competitive in the marketplace. To further reduce impediments to commercial development of nuclear energy, President Reagan directed that the Department of Energy will work closely with industry and the States toward a means of storing and disposing of commercial high-level radioactive waste. The President also designated a team of representatives from Government, industry, utilities, and universities to help determine what additional steps are required to overcome obstacles to nuclear power development. To ensure that the Nation is prepared for longer term nuclear power needs, the President also directed that the Government continue efforts on breeder reactor technology. The fast breeder nuclear reactors, if perfected, would use much less nuclear fuel than the ones currently in use. President Carter's concern for nuclear proliferation was a major factor in his decision in 1977 to halt the development of the fast breeder demonstration plant on the Clinch River in Tennessee. The effort to keep the research in fast breeder technology going was meeting stiff opposition in the Congress in the mid-1980s and prospects for developing a commercially viable fast breeder reactor in the near term were not good.

The possible use of fusion technology to provide energy with greater economy of uranium and a lower level of polluting waste products appears to be even more remote. Research using some Soviet-developed technology in this field is continuing in the United States.

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[8] U.S. Department of Energy, *Nuclear Plant Cancellations: Causes, Costs and Consequences*, April 1983, p. X.

Renewables

Renewable energy technologies have substantial potential for increasing energy supplies, but their contributions in the near term are not expected to be great. These technologies include solar thermal, solar heating and cooling, photovoltaics, hydroelectricity, wood, ocean thermal energy conversion, wind systems, biofuels, and a variety of geothermal and geopressure options. In 1983 renewable energy sources provided more than 8 percent of the primary energy needs of this country, and projections indicate renewables will contribute more than 9 percent to the energy mix by the year 1992 and more than 10 percent by the year 2000.

Solar energy, which is potentially available in large quantity and is renewable, has gained considerable attention, and pressures for making it commercially usable mounted in the 1970s. The intermittent and diffuse character of solar energy is a basic difficulty in making it competitive. Technology has been developed for solar water heating and for cooling, but several economic and institutional barriers must be overcome before such applications have a serious impact on energy use. Commercial use of power from solar-generated electricity appears to be much further away because of the capital-intensive nature of solar electric technologies.

The five ways electrical power may be produced from solar energy are: photovoltaic conversion, wind power, solar-thermal electric power cycles, ocean-thermal gradients, and biomass-fired powerplants. All these solar options for producing electricity have technological and economic problems. The conversion of wind to electricity has been demonstrated in several cases, and photovoltaic cells, which convert solar radiation directly to electricity, are used in the space programs; however, both of these sources have serious limitations for large-scale applications. Improved solar technologies and costs for conventional fuels will be key factors in determining when commercial solar-generated electric plants will be in use and solar heating and cooling systems will be widespread.

Many consumers have installed solar thermal systems with the hope of reducing energy costs; more than 700,000 systems have been installed for water heating. Tax credits at the Federal and State levels have boosted the expansion of solar systems for homes. There has, however, been considerable dissatisfaction because salespeople have not always delivered what they promised, and some have engaged in unethical practices that are detrimental to the consumer and the grantors of tax credits.

Direct combustion of wood has increased more than 40 percent since 1977 to a rate of more than 2.6 quads annually. Geothermal direct heating applications now total more than 60 trillion Btus annually. Municipal wastes consumed at more than 60 facilities produce 25 trillion Btus annually.

The number of permits issued by the Federal Energy Regulatory Commission for hydropower site development increased by 200 percent from 1980 to 1983, and geothermally produced electricity in the United States increased 20 percent during the same period. Alcohol fuels production capacity rose fortyfold during the past 6 years, from 10 million gallons per year to 400 million gallons per year.

Utilization of renewable energy options reduces the risk that supply interruptions or price increases in conventional energy resources will hinder economic growth. The geographic distribution of renewable resources also provides an opportunity to develop a diverse mix of systems to satisfy supply requirements of various localities throughout the United States.

The flexibility of renewable energy technologies permits direct matching of energy resources with such end-use energy requirements as electricity, low- and high-temperature heat, and gaseous and liquid fuels. The modularity of many renewable energy generating systems allows equipment additions or replacements to be made in less costly increments than is common with conventional systems.

The Department of Energy concentrates on scientific and engineering research to increase knowledge of the characteristics of renewable resources and the methods and materials needed to manufacture reliable and efficient systems.

Considerable progress has been made during the past few years across the spectrum of renewable energy technologies. For example, the cost of solar photovoltaic-generated electricity was cut by more than half between 1980 and 1983. The manufacture and sale of photovoltaic modules increased dramatically over the same period. Clearly, both users and producers of energy are discovering the potential and the benefits of renewable technologies.

Electricity: A Secondary Energy

Electricity, a secondary source of energy, not only provides power for many applications but also for control systems in nearly all kinds of power uses. Only highlights of a summary nature on electricity are included here because usually electric power is discussed as one of the utility industries. That does not diminish its vital importance to our society and to national security for power, communications, and other purposes.

A generalized picture of the flow of electricity in the electric utility industry is shown in figure 9. The data on the left of the figure show the sources of power to generate the electricity consumed; the data on the right of the figure show the amount of electricity consumed by major classes of users. The generation of 2.41 trillion kilowatts in 1984 was a record for domestic generation of electricity. Net generation increased steadily, except for the year 1982, from 329 billion kilowatts in 1950 to the 1984 total, a more than sevenfold increase. The mix of fossil fuels to produce electricity has shifted away from petroleum and natural gas, which (combined) decreased from 37 percent in 1972 to 17 percent in 1984; the coal portion rose during the same period from 44 percent to 56 percent. Generation by nuclear power reached a record level in 1984 and accounted for 13.5 percent of total electricity generation. Approximately .2 percent of net generation came from geothermal and other sources.

The share of electricity used by major categories of consumers has not changed significantly over the past decade; in 1984 the shares were, in percent, as follows: industrial, 37; residential, 34; commercial, 25; and other, almost 4. Electricity demand growth averaged about 7 percent in the 1960s, about 5 percent in the 1970s, and less than 3 percent from 1980 through 1984. The rate of growth of electricity demand was a major source of uncertainty confronting the electric utility industry in the mid-1980s. Estimates for growth in demand through the 1980s ranged from 2 to 3 percent. The traumas in efforts to expand nuclear generation combined with the fact that it takes 6 to 13 years to build a new coal-fueled plant—and even longer for a nuclear plant—caused some analysts to predict a shortage of electricity in the 1990s. Residential weighted average monthly electric bills increased every year from 1970 to 1984, except for 1979; they rose in 1972 constant dollars from $20.02 to $32.57 per thousand kilowatt-hours during the period.[9]

In 1984 when the U.S. Government used 1.85 quads of energy, or about 2.5 percent of the total consumed in the United States, the Department of Defense used a little more than 82 percent of all the energy consumed by the Government. In the Department of Defense, electricity accounted for approximately 21 percent of energy used, as compared to 68 percent for petroleum, almost 8 percent for natural gas, and about 3 percent for coal and other.[10]

Because of the vital importance of electricity to military operations and economic activities in support of the Armed Forces, national security managers have a need to know at least the fundamentals relating to supply and demand and the vulnerabilities that may arise from possible interruptions in electric power or blackouts caused by hostile actions.

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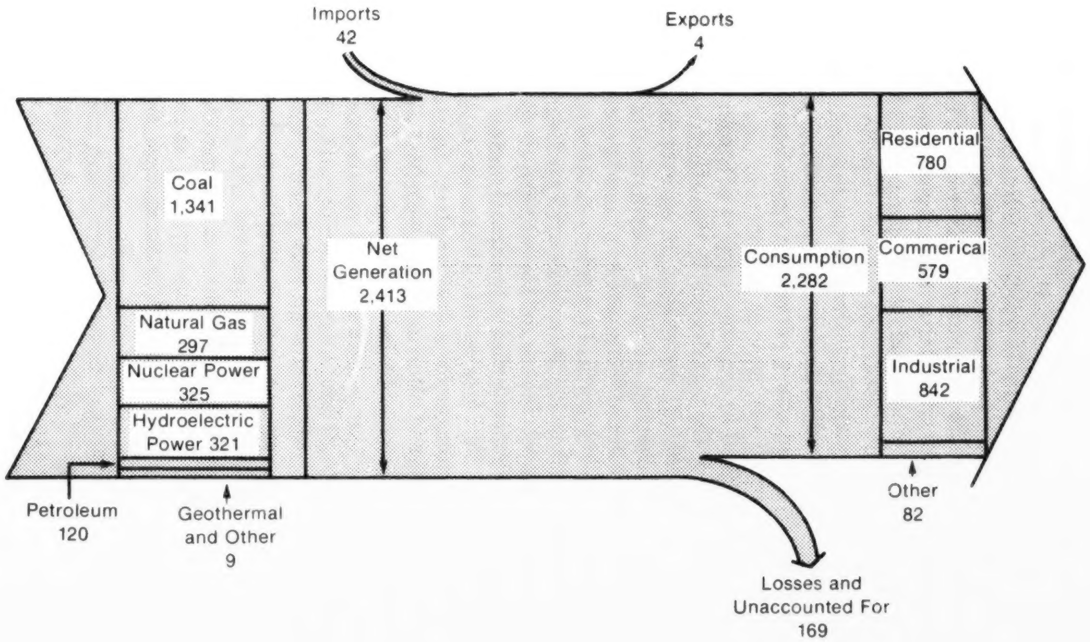
[9] *Annual Energy Review 1984*, pp. 165, 169, 171, and 185 and U.S. Department of Energy *Annual Energy Outlook 1984* (Washington: Government Printing Office, January 1985), pp. 147-148.

[10] *Annual Energy Review 1984*, pp. 19 and 21.


Imports
42
Exports
4
Coal
1,341
Natural Gas
297
Nuclear Power
325
Hydroelectric
Power 321
Petroleum
120
Geothermal
and Other
9
Net
Generation
2,413
Consumption
2,282
Residential
780
Commerical
579
Industrial
842
Other
82
Losses and
Unaccounted For
169

NOTE Sum of components may not equal totals due to independent rounding.

SOURCE U.S. Department of Energy, *Annual Energy Review 1984*, p. 167.

FIGURE 9. ELECTRIC UTILITY ELECTRICITY FLOW, 1984
(billion kilowatt-hours)

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In the 4 years following the creation of the Third United Nations Conference on the Law of the Sea in 1973 the conference, known as UNCLOS III, met at least once each year for sessions lasting approximately 2 months. Several committees drafted textual provisions that were acceptable in varying degrees to most participating states. General agreement on a series of three bands of jurisdictional areas had been reached by the time the sixth session of the UN Law of the Sea Conference was held in New York from 23 May to 15 July 1977; in each of these bands of jurisdictional areas, the rights of the coastal state in relation to other states in the international system had been weighed. The first band is a *territorial sea* with a breadth of 12 miles. The second band involves the *exclusive economic zone* 188 miles beyond the territorial sea. The third band, or area beyond 200 miles, remains *high seas* for all purposes. The negotiations to work out controls for the mineral resources of the deep seabed from the outset encountered serious difficulties. The United States and the other advanced industrial nations have contended that guaranteed, secure access to deep seabed resources is essential to protect the large capital investments that will be needed for full-scale production. On the other hand, the Group of 77 has argued for a monopolistic seabed authority, in which it would have the dominant voice and control production and marketing.

Elliot L. Richardson, who had gained a considerable reputation as a competent administrator in the Nixon and Ford Administrations, was named as leader of the U.S. delegation in 1977; it was hoped that his appointment would bring progress. In 1976, Public Law 94-265 extended the existing 12-mile exclusive U.S. fishing zone off the Nation's coast to 200 miles. Designed to protect the American fishing industry, the new law became effective 1 March 1977. Under the new law Federal controls and the 200-mile zone would end when a United Nations Treaty approved by the United States became effective.

The Law of the Sea negotiations dragged on and finally came to a head in 1982. The stickiest question was the proposal to create a seabed mining authority under U.N. jurisdiction. A provision backed by the Group of 77 provided the authority or "enterprise" that would lease deep-sea tracts to private enterprise and also that the U.N. enterprise could mine alongside the private or national operators. A majority of the 145 participants approved the provisions in a Convention on the Law of the Sea in 1982. The United States elected not to sign the treaty and objected to the provisions on deep-sea mining. Private enterprises of the United States and other Western nations individually and jointly have spent large sums to survey deep-sea beds of manganese-rich nodules and to invent means of uncovering and processing them.

President Reagan viewed the deep seabed mining provisions as inimical to our national interets. As stated by James L. Malone, Assistant Secretary for Oceans and International Environmental and Scientific Affairs, Department of State, in September 1984, U.S. objections, particularly to articles in part XI of the Law of the Sea (LOS) Convention, were as follows:

—Would enable a future "review conference" to adopt key changes to the treaty over the objection of member states, thus denying to the U.S. Senate its constitutionally mandated role in the treaty process;

—Would intentionally deter rather than promote economic development with the establishment of an ostensible "parallel system" that would, if implemented, discriminate against private operations, thereby restricting U.S. access to minerals of strategic importance;

—Would create a bias against the production of mineral resources as set forth in article 150 of the convention;

– Would impose unconscionable financial and regulatory burdens on American industry and Government, requiring, by the best estimates of U.S. Government officials, a potential liability for the United States of $1 billion in direct costs and loan guarantees for both initial expenses and continuing operations of the Enterprise and the International Seabed Resource Authority itself;

– Would effectively enjoin the mandatory transfer of private and possibly sensitive technology to an international seabed authority dominated by countries often unsympathetic to U.S. interests as the price of its use in private mining operations; and

– Would establish a potential source of funding for the terrorist activities of national liberation organizations.[3]

By late 1984 the Law of the Sea Agreement, approved by the delegates in 1982, had received only 12 of the 60 ratifications needed to put it in force. The United States and other key industrial states had not signed. The Convention was open for signature only until 10 December 1984; after that time, it was open for only adherence or accession. In early 1985, it appeared the United States would follow the provisions of the Convention except those relating to deep seabed mining.[4]

Meanwhile the United States has made important agreements on deep seabed resources. An "Agreement Concerning Interim Arrangements Relating to Polymetallic Nodules of the Deep Seabed" was signed 2 September 1982 by the United States, France, the Federal Republic of Germany, and the United Kingdom. Another agreement titled "Provisional Understanding Regarding Deep Seabed Matters" was signed 3 August 1984 and was consistent with the one of September 1982. It was signed by the nations who made the September 1982 agreement and also Belgium, Italy, Japan, and the Netherlands.

Ambassador Malone opined in September 1984 that the political will to amend the Law of the Sea Convention, adopted in 1982, did not exist, but the political climate had become more realistic. Concerning future prospects he stated:

> Given this country's resolute and clear stand on the convention and our provisional approach to deep seabed mining matters, I believe that perceptions will become increasingly realistic. This process will be gradual – it will not come about within the next year, or two, or even four, but I expect it will in the next six or eight, during which time the United States and its like-minded allies are resolved to stand firm. At such a stage, I feel the political will may well develop to reopen the conference and to give serious consideration to the minimal needs of the United States and the industrialized world. I believe

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[3] James L. Malone, "Freedom and Opportunity: Foundation for a Dynamic Oceans Policy," *Department of State Bulletin*, December 1984, pp. 76-77.

[4] Larry L. Booda, "The Sea's Rich Resources Beckon," *Seapower*, February 1985, pp. 51-56. See James K. Sebinius, *Negotiating the Law of the Sea* (Cambridge: Harvard University Press, 1984), for a detailed treatment of the negotiations of recent years.

that ensuing years will demonstrate to those who espouse the common heritage concept that too much of lasting benefit and promise will be lost if they do not come to grips with such realistic expectations. When that realization and the will to execute it are rekindled, the Law of the Sea will again become an effective negotiating forum. I look forward to that day.[5]

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[5] Malone, "Freedom and Opportunity," *Department of State Bulletin*, December 1984, p. 79.

X

RESOURCES FOR NATIONAL EMERGENCIES

RESOURCE MOBILIZATION

Stockpiling of materials, particularly of strategic and critical materials, is one of the several ways the United States provides for meeting requirements in emergencies.[1] The five key agencies that have major functional responsibilities for industrial preparedness (the Department of Commerce (DOC), Department of Defense (DOD), Department of Energy (DOE), Department of Transportation (DOT), and the Federal Emergency Management Agency (FEMA)) attempt to provide capabilities or plans to meet emergency needs. The foundation for preparedness is a strong economy combined with a strong commitment by the public. It includes the industrial system, energy, transportation, agriculture, and all the other components of the economy, the most important of which is human resources. The stockpile composition, from one perspective, reflects our weaknesses in what we must provide for those emergency needs that cannot be met on short-notice from existing capabilities or private sector inventories.

The Strategic and Critical Materials Stockpiling Act (PL 96-41, 50 U.S.C. *et seq.*) provides that strategic and critical materials be stockpiled in the interest of national defense to preclude a costly and dangerous dependence upon foreign sources of supply in terms of national emergency. The origins of our modern stockpile philosophy are found in developments during the period of World War II. In 1939, after several years of discussion on the need for stockpiling essential raw materials, the Congress appropriated $10 million for this purpose. Then, during our active participation in the war, the cutoff of some foreign materials underscored the need for a defense materials program and stockpiles were set up for some materials.

The Federal Emergency Management Agency has major responsibilities for managing priorities and allocations, coordinating industrial production emergencies, and managing the National Defense Stockpile. The Strategic Petroleum Reserve (SPR) is managed by the Department of Energy. Major resource claimancy interrelations for mobilization are shown in a general way in table 10. The trend in the Reagan Administration has been toward less Federal control and less detail in the assignment of responsibilities in resource claimancy.

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[1] See Harold J. Clem, *Mobilization Preparedness* (1983), another volume in the National Security Management series, for more detailed information on the framework for mobilization and the system of management for resource allocation in emergencies. Also, see Hardy L. Merritt and Luther F. Carter, eds., *Mobilization and the National Defense* (Washington: National Defense University Press, 1985).

Because the distinction between raw and processed materials is not always clear, the Departments of Commerce (DOC), Agriculture (USDA), and Interior (DOI) have worked out Memoranda of Understanding (MOUs) to differentiate between the two for the purposes of operating a system of priorities and allocations. The crux of the agreements centers around establishing a "watershed" for separating responsibilities. In minerals, the Department of the Interior is responsible for mines, concentrating plants, smelters, and refineries that produce or process basic ores and concentrates; the Department of Commerce is responsible for plants and products further "up" the chain of production. Similarly, the U.S. Department of Agriculture is responsible for agricultural products until they are no longer capable of being eaten or drunk; past this point, jurisdiction shifts to the Department of Commerce.

The Strategic Petroleum Reserve was discussed in chapter VIII. The next section of this chapter will briefly explain the Defense Priorities and Allocations System (DPAS) and cover in detail the National Defense Stockpile.

The broad scope of emergency preparedness programs is shown in the list of critical industries facilities. (The following is from the Federal Emergency Management Agency *Federal Emergency Preparedness, Volume 2: Industrial Preparedness*, 1984):

Defense Industrial Facilities Protection Program
Defense Priorities and Allocations System
Expansion of Industrial Capacity
Foreign Military Sales Financing Program
Industrial Preparedness Planning List
Industrial Preparedness Planning Program
Industry Evaluation Board
International Energy Program
Key Facilities List
List of Currently Critical Occupations
List of Currently Essential Activities
Machine Tool Trigger Order Program
Master Urgency List
Military Assistance Program
National Defense Stockpile
Peacetime Screening of Key Employees
Protection of Industrial Capability Program
Short Supply Program
Strategic Petroleum Reserve

U.S.-Canadian Agreement on Mobilization of Industrial Resources
U.S.-Canadian Bilateral Agreement on Priorities and Allocations
Voluntary Agreements

TABLE 10. MAJOR RESOURCE CLAIMANCY INTERRELATIONSHIPS FOR MOBILIZATION

Resources	Major resource agencies[1]	Major claimant agencies[2]
Communications	NCS, OSTP, & FCC	DOD, GSA, & FEMA[3]
Construction services (civil works)	FEMA & COE	DOD, DOI, & FEMA
Energy	DOE	USDA, DOC, DOD, DOI, HUD, DOT, HHS, & GSA
Financial services (economic stabilization)	Treasury & FRS	FEMA
Food	USDA	DOC, DOD, HHS, & DOS
Health and human services	HHS	DOD, DOL, OPM, & FEMA
Housing and related construction	HUD	USDA, HHS, DOD, & FEMA
Industrial production and related construction	DOC	USDA, DOD, DOE, DOI, HUD, HHS, DOT, GSA, EPA, & FEMA
Manpower	DOL & OPM	USDA, DOC, DOD, DOE, DOED, HHS, DOT, OPM, & FEMA
Minerals	DOI	DOC & DOE
Transportation services	DOT, MarAd, & ICC	USDA, DOC, DOD, DOE, HHS, USPS, & GSA
Water	DOI, EPA	USDA, DOC, DOE, HUD, & HHS

[1] Resource agencies – Develop and administer policies, programs, and measures necessary to effectively mobilize and manage those public and private resources assigned to their emergency control. A resource agency may also be a claimant agency for the resources required by its programs. Thus DOE, the energy resource agency, is a claimant upon DOC for industrial production. (See note below for meanings of abbreviations.)

[2] Claimant agencies – Represent, justify, and submit requirements for priorities or allocation support for a program or activity. These agencies have programs that make them primarily users or representatives of users of materials and services for approved defense programs.

[3] FEMA and resource agency develop national requirements.

NOTE: Abbreviations used in table are: Chief of Engineers (COE); Departments of: Commerce (DOC); Defense (DOD); Energy (DOE); Education (DOED); Interior (DOI); Labor (DOL); State (DOS); Transportation (DOT); and Environmental Protection Agency (EPA); Federal Emergency Management Agency (FEMA); Federal Reserve System (FRS); General Services Administration (GSA); Health and Human Services (HHS); Housing and Urban Development (HUD); Interstate Commerce Commission (ICC); Maritime Administration (MarAd); Office of Personnel Management (OPM); National Communication System (Defense Communications Agency) (NCS(DCA)); Office of Technology and Science Policy (OSTP); U.S. Postal Service (USPS).

SOURCE: Federal Emergency Management Agency, Resources Preparedness Office, May 6, 1981.

THE NATIONAL DEFENSE STOCKPILE

The National Defense Stockpile is the follow-on from holdings earlier held in the national stockpile, the Defense Production Act inventory, and the supplemental stockpile. This National Defense Stockpile inventory lists some 61 materials grouped by "families"; elements of each family are listed according to their status as raw materials, semifinished, or finished products that contain the same ingredients. The bulk of materials are mineral-or-metal related, but some are agricultural. The Government holds other materials that are not part of the National Defense Stockpile but may be used for emergency purposes. Included among these are the Strategic Petroleum Reserve and the inventories of surplus agricultural products over which the Federal Government has control. While the materials controlled under the Defense Priorities and Allocations System (DPAS) are in the inventories of the private sector, the adequacy of the DPAS inventories must be considered in calculating total requirements and the need for maintaining additional stocks of controlled materials in the National Defense Stockpile. Of the four presently controlled commodities, aluminum, copper, nickel alloys, and steel, only steel was not included in the National Defense Stockpile inventory in 1985. Other materials including energy could be designated controlled materials if the need arose. Moreover, in the case of energy, allocations and priorities based on the Defense Production Act could also apply to materials and equipment needed to make the best use of domestic energy supplies.

The Defense Priorities and Allocations System is designed to ensure that producers of items for authorized programs receive the necessary quantities of controlled metals; in 1985 the metals were aluminum, copper, steel, and nickel alloys. Moreover, contracts and orders relating to certain approved defense or energy programs are to be accepted and performed on a preferential basis over all other contracts or orders.

Before controlled materials can be used for authorized programs, the agency that has been delegated authority to use such materials must obtain specific approval, known as allotment, from the Federal Emergency Management Agency. Controlled materials must be for either rated orders or set-asides. Rated orders are formal authorizations for manufacturers to receive preferential delivery of a controlled material. Two types of rated orders are authorized – DO and DX. All DO orders have equal priority and take precedence over orders previously or subsequently received that do not bear an approved program identification. All DX orders are of equal priority and take precedence over DO and nonrated orders. All rated orders must be associated with an officially approved program. To ensure that enough controlled materials are available to manufacture items within approved programs, set-asides are calculated and imposed on the industries producing the controlled materials. The set-asides are normally calculated on a quarterly basis and are intended to establish an equitable sharing among suppliers of the various controlled materials. Once the set-aside has been established, an individual supplier must hold that quantity of materials in reserve to fill rated orders. The Defense Priorities and Allocations System has been in use since 1950, primarily to ensure priority for defense and defense-related programs. Today it is a simplified consolidation of the Defense Materials System and the Defense Priorities System that were developed in the 1950s.

A second major program, based on authority provided by the Defense Production Act, to facilitate the use of machinery, equipment, and processed materials during an industrial mobilization is the Machine Tool Trigger Order Program (MTTOP). This program develops standby orders with machine tool producers.

The origins of the stockpile date back to 1921 when the Army-Navy Munitions Board prepared the first list of critical materials. The first stockpiling act was passed in 1939 but never implemented because of the onset of World War II. Following the war, the direct predecessor of the current stockpiling act was passed, but because it did not specify how long an emergency to prepare for, the stockpile was subject to considerable political manipulations. As a consequence, the Strategic and Critical Materials Stockpiling Act (50 U.S.C. 98 *et seq.*) was revised again in 1979 with the provision that the stockpile should contain quantities of materials "sufficient to sustain the United States for a period of not less than three years in the event of a national emergency." Executive Order 12155 delegates the primary responsibility for planning and coordinating the stockpile program to the Federal Emergency Management Agency and the responsibility for maintaining the stockpile and its materials to the General Services Administration. The Federal Emergency Management Agency must also submit a written report to Congress every 6 months detailing the operations of the stockpile.[2]

Presidential guidance and legislative amendments to the Strategic and Critical Materials Stockpiling Act require annual planning for the stockpile, leading to the Annual Materials Plan (AMP), which lists stockpile materials proposed for acquisition and disposal. The Annual Materials Plan is developed through the Annual Materials Plan Steering Committee, chaired by the Federal Emergency Management Agency. The Committee has representatives from the Departments of Defense, Commerce, Interior, Energy, Agriculture, State, and Treasury, the Central Intelligence Agency, the General Services Administration, and the Office of Management and Budget. The Annual Materials Plan process begins when the Federal Emergency Management Agency gives a list of goals, deficits, excesses, and priorities to the General Services Administration. The materials proposed for purchase or sale are ranked according to national security priorities. The General Services Administration estimates the quantities of these materials that are needed and could be bought or sold without undue disruption of the market. The list is then given to the Strategic Implications and the Market and International Political Impacts Subcommittees for review in light of other considerations. (Examples of other considerations are effects on defense requirements, international producers, and commodity markets.) Following subcommittee review and final approval by all member agencies, the Federal Emergency Management Agency submits the Annual Materials Plan to the National Security Council (NSC) and the Office of Management and Budget (OMB). Any further revisions are made in joint deliberations of the NSC, FEMA, and OMB.

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[2] Federal Emergency Management Agency, *Federal Emergency Preparedness*, vol. 2, pp. III-47 and 48.

The stockpile is maintained by the Federal Property Resources Service of the General Services Administration at over 100 depots nationwide. The materials in the stockpile are stored in various states of readiness. Inventories of 24 of the 61 "family groups" meet or exceed current goals of materials in the stockpile as of the mid-1980s. Of the 37 others, only 17 are more than 50 percent filled.

The total inventory of the stockpile at the end of March 1984 was valued at $10.9 billion, including an excess inventory valued at $3.8 billion. The total goal of the stockpile was $17.3 billion; thus, it would require an additional $10.2 billion over the $7.1 billion held in inventory that could be counted toward goals. The progress toward major stockpile goals is indicated in figure 10.

Cash purchases of needed materials is one of the most often used methods to acquire materials for the National Defense Stockpile. Sales of excess materials from the stockpile are placed in the National Defense Stockpile transaction fund (NDSTF) established under Section 9 of the Strategic and Critical Stockpiling Act, as amended (PL 96-41, 50 U.S.C. 98 *et seq.*).[2] Receipts from such sales transferred into the NDSTF through 31 March 1984 totaled $440.9 million. Congress, which must approve the use of NDSTF monies, approved the use of $398.3 million, leaving a balance of $42.6 million as of 31 March 1984. On the latter date it was estimated that an additional $10.2 billion would be needed to fill stockpile goals. At the rate of purchases of the early 1980s, decades would be required to meet stockpile needs.

The Stockpiling Act as amended in 1979 places restrictions on the use of the National Defense Stockpile. Section 3 as amended states "the purpose of the stockpile is to serve the interest of national defense only and is not to be used for economic or budgetary purposes." Also, it provides that quantities of any material stockpiled under the act may not be revised unless the Committees on Armed Services of the Senate

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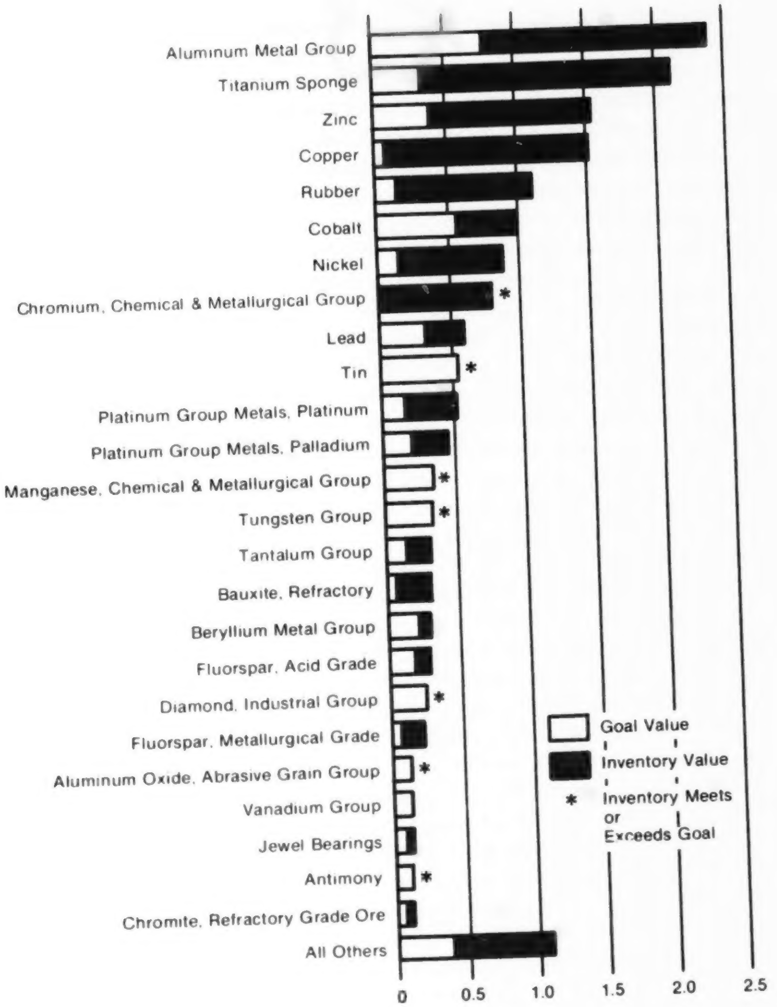
[2] For provisions of the act, see *Stockpile Report to the Congress*, October 1983-March 1984, pp. 19-33. The information on the status of the stockpile is taken largely from this report.



NOTE Figure is as of March 31, 1984.

SOURCE Federal Emergency Management Agency, *Stockpile Report to the Congress October 1983-March 1984*, p. 10.

FIGURE 10. PROGRESS TOWARD MAJOR STOCKPILE GOALS
(billions of dollars)

and House of Representatives are notified in writing of the proposed revision and the reasons for such revision at least 30 days before the effective date of such revision. The President has special disposal authority for release of materials for defense-related purposes. In time of war declared by Congress or during a national defense emergency, the President can delegate this authority to any officer or employee of the United States. Any order issued under the special disposal authority of the President must be promptly reported in writing by the President or the person to whom the President has delegated authority to the Armed Services Committees of the Senate and the House of Representatives.

With respect to transactions, the Stockpiling Act states that, to the maximum extent feasible, competitive procedures are to be used in the acquisition and disposal of materials. Acquisitions and disposals should avoid undue disruption to usual markets of producers, processors, and consumers to protect against avoidable losses. Also, disposal of stockpile materials should be for domestic consumption.

Requirements Determination

The determination of estimated requirements for strategic and critical materials involves both requirements estimates and supply estimates. These calculations are preliminary to the setting of stockpile goals.

The requirements estimates process begins with projections of the gross national product (GNP) using an econometric model. The GNP forecast is driven by macroeconomic estimates of approximately 50 variables. These variables are consistently estimated within the context of a 3-year nonnuclear war preceded by 1 year of warning or mobilization. The National Security Council planning assumptions provide the major policy adjustments to the variables to develop a comprehensive wartime gross national product. These planning assumptions adjust imports, exports, investment, and personal consumption. Estimates for wartime GNP are developed for three tiers: defense, essential civilian, and industrial components of the economy. This type of estimating is done to take national security priorities into account and explicitly recognize, for example, that a pound of cobalt for a turbine engine is more important than a pound of cobalt for ceramic coloration. The three tiers are defined as follows:

– Defense. All production necessary to obtain weapons, manpower, and support including the production necessary to support suppliers of DOD contractors.

– Essential civilian. Those expenditures necessary to maintain the health, safety, morale, and productivity of that segment of the population in support of the war or emergency.

—General civilian. Those expenditures for which belt tightening is often necessary to support the population and maintain a viable industrial base.[3]

The GNP tiers are separated into approximately 250 categories, and by using demand impact transformation tables the categories are converted from GNP data into final demand for outputs of 109 industries. Department of Commerce historically developed material consumption ratios are used to compute the physical consumption of each of the strategic materials for each specific industry. The GNP times (×) material consumption ratios provides estimates of each industry for material consumption, each tier, and each year of the war. Final adjustments are made that account for material substitution. Planning factors geared to variable risk modify the rates at which industries substitute one material for another. With this final adjustment, the total requirements for a material in a particular tier in a given year are created.

Supply estimates, the second major calculation, are to determine potential available supply from current domestic production, plant capacity, and expected imports. This information is developed by the commodity experts in the Department of Interior (Bureau of Mines) and the Department of Commerce (Bureau of Domestic Commerce).

Foreign sources of supply may vary considerably in wartime versus peacetime. Thus, the quantity is adjusted after examining normal supply patterns and expanded production possibilities, where mines and other production facilities are assumed to operate at capacity. The United States, it is assumed, will receive a proportionate share of the increased supplies.

Once the import supply estimates are developed, they are adjusted by first deleting countries in the zone of action and then by applying a political reliability factor. The Department of State uses Central Intelligence Agency information to rate supplier countries. The Federal Emergency Management Agency analyzes the resulting numerical rankings of supplier countries and determines their contribution to supplied quantities. Countries ranked below the 35th percentile are not considered as viable supply sources. Countries above the 35th percentile are acceptable for supplying the general civilian tier, and countries above the 70th percentile are acceptable for the essential civilian tier. The only sources for the defense tier are Canada and Mexico because of their proximity, although countries above the 90th percentile are considered.

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[3] John T. Guttman, Colonel USAF, Victor J. Fenwick, Jr., Lieutenant Colonel USA, John F. Graham, Defense Mapping Agency, and Joseph Merrick, Colonel USAF, *Critical Non-Fuel Minerals in Mobilization with Case Studies on Cobalt and Titanium* (Washington: Industrial College of the Armed Forces (unpublished report in the Mobilization Studies Program), April 1983). This source is used for the description of the methodology for determining stockpile requirements. The wartime GNP estimate of production levels for individual industries is developed separately for the three tiers defined above.

The final discounting measure applied is for transportation losses. After the political reliability discounts, estimates of losses of materials sent by ship or air are subtracted from available suppliers by tier. The process described above establishes the quantity supplied by tier by year for each material.

The stockpile goals are now calculated for a given material by comparing the imbalances between demand and supply by tier by year. This summation yields an unadjusted stockpile goal. Special materials planning factors are used to adjust stockpile goals if a material has 60 percent or more of its uses in defense applications or if the United States is 100 percent dependent for imports coming from outside of North America. The determination of the final stockpile goals is a process with review by Department of Defense, Department of State, Department of Commerce, Department of Interior, and the Federal Emergency Management Agency.

Barter

Barter is often used to acquire materials for the stockpile. Between 1950 and 1967, the U.S. Department of Agriculture (USDA) conducted a barter program under which 60 strategic and critical materials, with a value of more than $1.6 billion, were acquired from more than 50 countries. These materials were bartered for agricultural commodities owned by the Commodity Credit Corporation (CCC), USDA. The last barter contract under that program was signed in 1967.

The Reagan Administration initiated in 1982 a new barter program involving the acquisition of bauxite from Jamaica in exchange for dairy products owned by the Commodity Credit Corporation. The first transaction involved the purchase of 1,000,000 tons of Jamaican-type bauxite; 400,000 tons of bauxite were also acquired through barter of surplus agricultural commodities, and 200,000 tons of bauxite were acquired through exchange of excess stockpile materials. The second transaction, signed in January 1984, involved 600,000 tons of bauxite for 22,687 tons of CCC-owned dairy products, at a value of $20.4 million. The Commodity Credit Corporation will hold title to the bauxite until fiscal year 1988, at which time the General Services Administration will begin a 3-year program to reimburse the Commodity Credit Corporation for the value of the bauxite in exchange for title. The acquisition of strategic and critical materials for the stockpile by the General Services Administration from the Commodity Credit Corporation has been on a case-by-case basis, with the question of reimbursement handled as a part of the normal budget process.

One may conclude from the information in this and earlier chapters that, despite some modest efforts in recent years to improve the National Defense Stockpile and other reserves held by the Federal Government, the capabilities of the United States to supply resources for a major conflict of extended duration have deteriorated over the past two decades. Vulnerabilities to interruptions in supplies from foreign sources have increased. In the case of oil, production peaked in the early 1970s and U.S. reserves are limited. The United States will continue to be dependent on foreign suppliers for 10 to 15 percent of its oil. Increasing dependencies require that greater measures be taken to reduce vulnerabilities, including stockpiling, developing substitutes, planning to use potential domestic capabilities, and using all means to improve the reliability of foreign suppliers. With respect to the latter, it is necessary to realize that nations, including allies, act in their own self-interest, and there are limits on the reliability of even our closest allies. The security of lines of communication through which imported materials must pass also becomes more important under conditions of resource dependency. Dependence on foreign nations, some of doubtful reliability, for such strategic and critical materials as chromium, cobalt, manganese, and platinum group metals will likely continue. The increasing lack of competitiveness of many U.S. industries including those producing minerals and metals has resulted in a deterioration of the industrial base. The great strengths of the United States, including its technological achievements, economic capacity, and resourceful population, must be used in resolving our resource problems.

LIST OF ABBREVIATIONS

AMP	Annual Materials Plan
bdg	Billion gallons per day
BLM	Bureau of Land Management
BTU	British thermal unit
CCC	Commodity Credit Corporation
CPE	Centrally planned economy
DMS	Defense Materials System
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DPAS	Defense Priorities and Allocations System
DPS	Defense Priorities System
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GNP	Gross national product
GSA	General Services Administration
ISMI	International Strategic Minerals Inventory
LNG	Liquid natural gas
LOS	Law of the Sea
lt	Long ton
MOU	Memorandum of Understanding
NDSTF	National Defense Stockpile transaction fund
NSC	National Security Council
OMB	Office of Management and Budget
OPEC	Organization of Oil Exporting Countries
PL	Public law
RARE	Roadless Area Review and Evaluation
RDF	Rapid Deployment Force
SMSA	Standard metropolitan statistical area
SPR	Strategic Petroleum Reserve
st	Short ton
USDA	U.S. Department of Agriculture

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